10 Comparative Analysis of Alternatives

This section presents the final analysis of the alternative screening process incorporating the risks, implementation methods, costs, and action level options screened in the previous sections of the FS. This final section is a comparative analysis among the eight potential remedial alternatives to assess the relative performance of each alternative with respect to four of the CERCLA balancing criteria presented in Section 9 (EPA, 1988 RI/FS Guidance Document). It synthesizes all of the findings presented in the RI, FS, and RA documents for the Lower Fox River and Green Bay RI/FS. The purpose of the comparative analysis is to weigh the relative performance of each alternative against a particular criterion and to determine which alternatives perform consistently well or consistently better in relation to the criterion of interest. A sub-component of this comparison is that for each remedial alternative, a range of action levels is presented resulting in varying levels of effort, protection, and risk reduction (discussed in Section 8). By carrying forward a range of action levels for each alternative, this section creates a three-dimensional comparative analysis between evaluation criteria, remedial alternative, and action level.

Following a description of the comparative process, the comparative analysis for each of the four river reaches are described separately below as they relate to the remedial action objectives. The Green Bay zones are discussed together as Green Bay since most of the outcomes are the same, regardless of the zone. A summary of the comparative measures used in the evaluation process are presented in Table 10-1. A summary of the total cost and anticipated risk reduction associated with each alternative is presented in Tables 10-2 and 10-3 for the Lower Fox River and Green Bay, respectively.

10.1 Description of Comparative Analysis Process

This section compares the predicted performance of: 1) each reach-specific and bay-specific alternative at each action level in relation to specific evaluation criteria; and 2) each action level on a river- and bay-wide basis in relation to specific evaluation criteria. This comparison builds upon the detailed analysis conducted in Section 9 in which each alternative was analyzed independently without consideration of other alternatives and the risk assessment summary in Section 8 in which each action level was evaluated independently. The purpose of the comparative analysis is to identify the advantages and disadvantages of each alternative and action level relative to one another, so that the key trade-offs

can be identified. This section does not, however, recommend any specific alternative or action level. Final selection will be the responsibility of the resource managers to balance the trade-offs identified in this section and select a final remedy option.

The comparative analysis focuses on synthesizing the evaluation in Section 9 into readily accessible decision-making tools. To accomplish this, numerical measures were used to evaluate how each alternative compares relative to all others with respect to addressing each of the following questions:

- How long after remediation is completed would it take to achieve sediment concentrations resulting in acceptable risk to humans and ecological receptors?

- What is the level of disruption to local communities associated with the construction of each alternative?

- What is the mass of PCBs removed from the Lower Fox River?

- What is the cost of implementing each alternative?

- What is the incremental cost of reducing risk for each alternative?

- How long after remediation is completed would it take to achieve surface water concentrations resulting in acceptable risk to humans and ecological receptors?

- What is the amount of PCBs being transported to Green Bay in the water column as suspended solids following implementation of the alternative?

Each of these issues, and the quantitative measures identified to evaluate the alternatives, are discussed in Table 10-1. In summary, the array of parameters included in the comparative analysis for both the Lower Fox River and Green Bay includes the following components:

- **Remedial Alternatives**
  - A: No Action
  - B: Monitored Natural Recovery and Institutional Controls
  - C: Dredge and Off-site Disposal (C1, C2, and C3 where options are provided[8])
  - D: Dredge to a CDF
  - E: Dredge and Thermal Treatment
  - F: Cap in Place (to the maximum extent possible)
  - G: Dredge to a CAD Facility

- **PCB Action Levels**
  - No Action
  - 125 ppb
  - 250 ppb
  - 500 ppb
  - 1,000 ppb
  - 5,000 ppb

- **Evaluation Parameters (Associated CERCLA Balancing Criterion)**
  - Years to Reach Protective Human Health Levels (long-term effectiveness and permanence)
  - Years to Reach Protective Ecological Health Levels (long-term effectiveness and permanence)
  - Number of Years to Implement Remedy (short-term effectiveness)
  - PCB Mass Removed (reduction of toxicity, mobility and volume)
  - Total Cost (cost)
  - Cost Effectiveness (cost)
  - Years to Reach Ecologically Protective Surface Water Quality (long-term effectiveness and permanence)
  - PCB Sediment Loading to Green Bay (long-term effectiveness and permanence)

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[8] Alternative C or C1 is hydraulic dredging for Little Lake Butte des Morts, Appleton to Little Rapids, and Little Rapids to De Pere.
Alternative C or C1 is mechanical dredging for De Pere to Green Bay and the Green Bay zones.
Alternative C2 is mechanical dewatering for Little Lake Butte des Morts Reach.
Alternative C2A is hydraulic dredging pumped directly to a combined dewatering and disposal facility, and Alternative C2B is passive dewatering and disposal at a dedicated NR 500 monofill for the Little Rapids to De Pere and the De Pere to Green Bay reaches.
Alternative C3 is mechanical dewatering and disposal at an existing NR 500 commercial disposal facility for the Little Rapids to De Pere and De Pere to Green Bay reaches.

As discussed in Section 8, none of the alternatives considered in this FS are projected to meet surface water criteria (RAO 1) that is protective to human health drinking water standards within the modeled time horizon (100 years). As such, the ability to achieve this portion of RAO 1 cannot be used in a comparative analysis to distinguish the various alternatives. However, the ability to achieve wildlife criteria (0.12 ng/L) within 30 years following remediation is discussed under ecological health. In addition, the minimization of contaminant releases during active remediation (RAO 5) was not considered since reliable, comparable, quantitative data are not available for this purpose.

Project expectations for the Lower Fox River and Green Bay project have been summarized as five remedial action objectives previously described in Sections 4 and 8 of the FS. Within each of these remedial action objectives, both WDNR and EPA have quantified their project expectations into numerical values (i.e., number of years to remove fish consumption advisories) in which to evaluate the expected performance of each alternative and each action level. These expectations may change or be revised over the course of the project and through the public review process, but for now, they provide a useful framework to compare and evaluate the alternatives. These quantifiable expectations are described in Section 8.

From the array of risk levels and protective sediment quality thresholds presented in Section 8, several key thresholds were carried forward in the FS for relative comparison between alternatives. These thresholds were selected by both WDNR and EPA as important risk evaluation criteria that relate to the remedial action objectives (RAOs) for the project:

- **Human Health**
  - Achieve protective levels in 10 years following cleanup for recreational anglers - walleye, whole fish, RME, HI is 1.0 (noncancer) (288 μg/kg);
  - Achieve protective levels in 10 years following cleanup for recreational anglers - walleye, whole fish, RME, 10^{-5} cancer risk (106 μg/kg);
  - Achieve protective levels in 30 years following cleanup for high-intake fish consumers - walleye, whole fish, RME, HI is 1.0 (noncancer) (181 μg/kg); and

- Achieve protective levels in 30 years following cleanup for high-intake fish consumers - walleye, whole fish, RME, 10^{-5} cancer risk (71 μg/kg).

Because many of the recreational angler thresholds are met within 30 years following cleanup without implementation of an active remedy, the high-intake fish consumer threshold was added to the comparative analysis.

- **Ecological Health**
  - Achieve protective levels in 30 years following cleanup based on carnivorous bird deformity - NOAEC based on carp, whole fish (121 μg/kg);
  - Achieve protective levels in 30 years following cleanup based on protection of piscivorous mammals (mink) - NOAEC based on carp, whole fish (50 μg/kg); and
  - Achieve surface water quality for the protection of wildlife (0.12 ng/L) in 30 years following cleanup.
- **PCB Transport to Green Bay**
  - Achieve PCB loads from the Lower Fox River (De Pere to Green Bay Reach) into Green Bay that are equivalent to PCB loads from the sum of other tributaries (10 kg/yr).

The projected time required to meet these thresholds based on the action levels selected are discussed in the following sections for each reach and zone.

10.2 Summary of Alternatives

The seven generic remedial alternatives retained for detailed analysis are:

A. No Action,
B. Monitored Natural Recovery and Institutional Controls,
C. Dredge and Off-site Disposal,
D. Dredge to a Confined Disposal Facility (CDF),
E. Dredge and Thermal Treatment,
F. *In-situ* Capping, and
G. Dredge to a Confined Aquatic Disposal (CAD) Facility.

The no action alternative was retained as required under CERCLA and the NCP. This alternative serves as a baseline for comparison with other alternatives and involves taking no action towards a remedy, implying no active management or expectation that the RAOs will be achieved over time.

The monitored natural recovery alternative was also retained as a basis for comparison with other alternatives, but involves an expectation that RAOs will be achieved in 30 years (i.e., ability to consume fish from the Lower Fox River). This alternative assumes that institutional controls will remain in place until acceptable levels of risk have been achieved. Monitored natural recovery is implied in many of these alternatives, because each remedy assumes varying amounts of protectiveness by natural processes by selecting a range of different action levels surrounding the SQT levels identified in the risk assessment (Section 3). Each action level and the amount of risk reduction provided by source removal of contaminated sediment will be compared to the amount of remaining risk and the costs associated with each action level.

Dredge and off-site disposal includes hydraulic and/or mechanical dredging, passive followed by solidification or mechanical dewatering, and truck hauling to an existing or newly-constructed landfill.

Dredge to a CDF includes hydraulic dredging and piping or mechanical dredging and offloading to a newly-constructed nearshore or freestanding CDF. Nearshore CDF construction in the Lower Fox River includes placement of steel sheet piles along the waterside and a clean soil cap once the CDF has been filled to capacity. In-water CDF construction in Green Bay includes placement of contaminated sediment in an elevated cellular cofferdam and capping with clean sand.

Vitrification was retained as the representative thermal treatment process option. It involves hydraulic dredging, passive dewatering followed by thermal treatment by a shore-based unit. Sediment treated by thermal treatment is transformed into glass aggregate that has the potential for a wide variety of beneficial reuse applications.

Thermal treatment was selected as the *ex-situ* thermal treatment process option because the multi-phased study conducted by WDNR has provided data which indicates that this treatment technology is a viable option.

Several sand cap designs were retained in Section 6 for possible application in the Lower Fox River. Design factors that influenced the final selection of an *in-situ* cap included an evaluation of capping materials and cap thickness when applied

in the field. In general, sandy sediments are suitable capping material, with the additional option of armoring at locations with the potential for scouring and erosion. Contaminated sediments will be left in place and covered with a 20-inch sand cap overlain by 12 inches of graded armor stone. Sediments located within navigational channels will be dredged, dewatered and taken to an upland disposal site.

Construction of a CAD is only technically feasible in Green Bay. Three possible locations were sited in the FS based on bathymetry, water depth, and currents. Each location was assumed to provide enough capacity for each action level. Construction of the CAD includes placement of contaminated sediment in a mechanically-dredged excavation and covering the sediment with 3 feet of clean sand after placement.

10.3 Comparative Analysis of Alternatives - Little Lake Butte des Morts Reach

The comparative analysis of alternatives for the Little Lake Butte des Morts Reach is presented on Figures 10-1 and 10-2. The following discussion provides a set of observations made as a result of the comparative analysis:

- **Human Health.** Figure 10-1 illustrates the time required following cleanup to reduce human health risk to below acceptable levels such that consumption advisories for recreational anglers can be removed. A general target has been established that these recreational advisories be removed within 10 years following cleanup. Active remedies implemented to the 1,000 ppb action level will satisfy this goal. The largest reductions in time to achieve protective levels is observed between the 5,000 and 1,000 ppb action levels. Figure 10-1 illustrates the time required following cleanup to reduce human health risk to below acceptable levels such that consumption advisories for high-intake fish consumers can be removed. A general target has been established that these advisories be removed within 30 years following cleanup. Active remedies satisfy this goal for action levels 125 through 1,000 ppb with the largest reduction in time to achieve protective levels occurring between the 5,000 and 1,000 ppb action levels.

- **Ecological Health.** Figure 10-1 also illustrates the time required to meet ecologically protective levels. A general target has been established that safe ecological levels should be met within 30 years following cleanup. Active remedies will meet protective levels within

the modeled time frame for the 1,000 ppb action level and below, for all alternatives. The largest reduction in time to reach protective levels is observed between the 5,000 and 1,000 ppb action levels.

Figure 10-1 illustrates the time to meet ecologically protective levels based on surface water quality. A general target has been established that safe ecological levels should be met within 30 years following cleanup. Active remedies achieve this target for the 125 and 250 ppb action levels and are marginally above the target for the 500 ppb action level (39 years).

- **Implementation Duration.** Figure 10-2 illustrates the implementation duration for each alternative at each action level. A general target goal has been set to perform the cleanup within a 10-year period. Only the 125 ppb action level does not satisfy this target. All the alternatives have approximately equivalent cleanup durations that vary by action level.

- **PCB Mass Removed.** Figure 10-2 illustrates that alternatives involving dredging remove the same PCB mass at each action level, while the capping alternative (Alternative F) removes slightly less PCB mass. The largest reduction in PCB mass is observed between 5,000 and 1,000 ppb action levels, while any further decrease in the action level does not significantly increase the PCB mass removed (less than 7%).

- **Total Cost.** The total cost to implement an active remedy represents a fivefold cost increase compared to MNR (Alternative B) estimated at $9.9 million (Table 10-2). It can be seen on Figure 10-2 that Alternative E is generally the lowest cost active remedy, while dredging to a CDF and dredge and off-site disposal with mechanical dewatering (Alternatives D and C2) are slightly more expensive, with C1 being the most expensive. Alternative D appears to be least sensitive to changes in action level. At the 1,000 ppb action level, Alternative E is estimated to be the least-cost approach at $64 million with Alternative C2 at 66 million, Alternative D at $68 million, Alternative F at $90 million, and Alternative C1 at $117 million.

- **Cost Effectiveness.** In order to evaluate the cost effectiveness of each alternative at each action level, the incremental cost per year reduction in time to remove fish consumption advisories (for recreational anglers) relative to the Institutional Controls alternative (Alternative B) was

calculated using the cancer risk data. Due to the uniformity in the time to remove fish consumption advisories, these data are closely aligned to the total cost data. Thermal Treatment (Alternative E) is the most cost-effective remedy, and 1,000 ppb is the most cost-effective PCB action level that meets protective thresholds.

10.4 Comparative Analysis of Alternatives - Appleton to Little Rapids Reach

The comparative analysis of alternatives for the Appleton to Little Rapids Reach is presented on Figures 10-3 and 10-4. The following discussion provides a set of observations resulting from the comparative analysis:

- **Human Health.** Figure 10-3 illustrates the time required following cleanup to reduce human health risk to below acceptable levels such that consumption advisories for recreational anglers can be removed. A general target has been established that these recreational advisories be removed within 10 years following cleanup. Each active remedy satisfies this goal for action levels 125 through 1,000 ppb, except for the cancer risk time frame which is marginally above the target for the 500 ppb (11 years) and 1,000 ppb (14 years) action levels. The largest reduction in the time to reach protective levels is observed between the 5,000 to 1,000 ppb action levels. Figure 10-3 illustrates the time required following cleanup to reduce human health risk to below acceptable levels such that consumption advisories for high-intake fish consumers can be removed. A general target has been established that these advisories be removed within 30 years following cleanup. Active remedies satisfy this goal for action levels 125 through 1,000 ppb with the largest reduction in time to achieve protective levels occurring between the 5,000 and 1,000 ppb action levels.

- **Ecological Health.** Figure 10-3 also illustrates the time required to meet ecologically protective levels. These data indicate that protective levels will not be reached within 71 to over 100 years with no active remedy (Alternatives A and B). Active remedies will meet protective levels within the 30-year time frame for the 1,000 ppb action level and below, except for the piscivorous mammal that is marginally above 30 years (34 years) at the 1,000 ppb action level. For the 500 ppb action level, the time to reach protective ecological levels varies between 15 and 29 years. For 250 ppb, the time varies between 9 and 18 years and for 125 ppb, the time varies between 7 and 15 years.

Figure 10-3 illustrates the time to meet ecologically protective levels based on surface water quality. A general target has been established that safe ecological levels should be met within 30 years following cleanup. Active remedies achieve this target for the 125 and 250 ppb action levels and are marginally above the target for the 500 ppb action level (40 years).

- **Implementation Duration.** Figure 10-4 illustrates the implementation duration for each alternative at each action level. A general target has been set to perform the cleanup within a 10-year period. All of the alternatives at each action level easily satisfy this target with the maximum implementation duration being 1.3 years.

- **PCB Mass Removed.** Figure 10-4 illustrates that alternatives involving dredging remove the same PCB mass at each action level. The largest reduction in PCB mass is observed between the No Action and 5,000 ppb action levels (63% removed), while further decrease in the action level incrementally increases the PCB mass removed. Only 10 percent of the mass is contained between the 125 and 500 ppb action levels. For Alternatives C and E, the PCB mass removed varies from 67 kg at 5,000 ppb to 105 kg at 250 ppb.

- **Total Cost.** The total cost to implement an active remedy represents a 5- to 20-fold cost increase compared to the MNR alternative (Alternative B) estimated at $9.9 million (Table 10-2). Dredging to an off-site landfill (Alternative C) is a slightly higher cost approach when compared to thermal treatment (Alternative E). Alternative E appears to be the least sensitive to changes in action level. For example, at the 1,000 ppb action level, Alternative E is estimated to be the least-cost approach at $17 million with Alternative C at $20 million.

- **Cost Effectiveness.** In order to evaluate the cost effectiveness of each alternative at each action level, the incremental cost per year reduction in time to remove fish consumption advisories (for recreational anglers) relative to the MNR alternative (Alternative B) was calculated using the cancer risk data. Due to the uniformity in the time to remove fish consumption advisories, these data are closely aligned to the total cost data. Thermal Treatment (Alternative E) is the most cost-effective remedy, and 1,000 ppb is the most cost-effective PCB action level that meets protective thresholds.

10.5 Comparative Analysis of Alternatives - Little Rapids to De Pere Reach

The comparative analysis of alternatives for the Little Rapids to De Pere Reach is presented on Figures 10-5 and 10-6. The following discussion provides a set of observations made as a result of the comparative analysis:

- **Human Health.** Figure 10-5 illustrates the time required following cleanup to reduce human health risk to below acceptable levels such that consumption advisories for recreational anglers can be removed. A general target has been established that these recreational advisories be removed within 10 years following cleanup. Each active remedy satisfies this goal based on noncancer risk for action levels 125 through 1,000 ppb. The goal is satisfied for only the 125 ppb action level based on cancer risk, while the result is marginally above the goal for the 250 ppb (14 years) and 500 ppb (20 years) action levels. The largest reductions are observed between the 5,000 and 1,000 ppb action levels. Figure 10-9 illustrates the time required following cleanup to reduce human health risk to below acceptable levels such that consumption advisories for high-intake fish consumers can be removed. A general target has been established that these advisories be removed within 30 years following cleanup. Active remedies satisfy this goal for action levels 125 through 1,000 ppb, except for the cancer risk scenario at the 1,000 ppb action level where the goal is not achieved for 42 years. The largest reduction in time to achieve protective levels occurs between the 5,000 and 1,000 ppb action levels.

- **Ecological Health.** Figure 10-5 also illustrates the time required to meet ecologically protective levels. The no action alternatives (Alternatives A and B) do not reach protective levels within the modeled time frame (100 years). Active remedies will meet protective levels within the 30-year target time frame for action levels 125 through 500 ppb, except for the piscivorous mammal scenario at the 500 ppb action level where the goal is not achieved for 31 years.

  Figure 10-5 illustrates the time to meet ecologically protective levels based on surface water quality. A general target has been established that safe ecological levels should be met within 30 years following cleanup. Active remedies achieve this target for the 125 ppb action level and are marginally above the target for the 250 ppb action level (40 years).

- **Implementation Duration.** Figure 10-6 illustrates the implementation duration for each alternative at each action level. A general target has been set to perform the cleanup within a 10-year period. Only the 125 ppb action level does not satisfy this target for all of the active remedies (Alternatives C1, D, and E). For each action level, the Dredge and Pipe to Landfill and Capping alternatives (Alternatives C2 and F) have the lowest implementation durations when compared to other alternatives.

- **PCB Mass Removed.** Figure 10-6 illustrates that all removal alternatives (Alternatives C1 through E) remove the same PCB mass at each action level, while capping (Alternative F) removes significantly less PCB mass. Significant reductions in PCB mass are observed at the 5,000 and 1,000 ppb action levels. Ninety-two percent of the PCB mass is removed at the 1,000 ppb action level while further decreases in the action level do not significantly increase the PCB mass removed. For Alternatives C1 through E, the PCB mass removed varies from 798 kg at 5,000 ppb to 1,192 kg at 250 ppb.

- **Total Cost.** The total cost to implement an active remedy represents a 4- to 25-fold cost increase compared to the MNR alternative (Alternative B) estimated at $9.9 million. Among the active remedies, dredging to a CDF (Alternative D) has the lowest cost at all action levels (except 5,000 ppb) (Table 10-2). Alternative D also appears to be least sensitive to changes in action level. Alternatives D, F, C3, E, C2B, and C1 are incrementally more expensive, with Alternative C1 being the most expensive. For example, at the 1,000 ppb action level, Alternative C2A is estimated to be the least-cost approach at $44 million. Alternative D is estimated to cost $53 million, Alternative F is estimated to cost $63 million, Alternative C3 is estimated at $69 million, Alternative E is estimated at $86 million, Alternative C2B is estimated at $100 million, and Alternative C1 estimated at $95 million.

- **Cost Effectiveness.** In order to evaluate the cost effectiveness of each alternative at each action level, the incremental cost per year reduction in time to remove fish consumption advisories (for recreational anglers) relative to the Institutional Controls alternative (Alternative B) was calculated using the cancer risk data. Due to the uniformity in the time to remove fish consumption advisories, these data are closely aligned to the total cost data. Alternatives C2A and D are the most cost-effective remedies, and 1,000 ppb is the most cost-effective PCB action level that meets protective thresholds.

10.6 Comparative Analysis of Alternatives - De Pere to Green Bay Reach

The comparative analysis of alternatives for the De Pere to Green Bay Reach is presented on Figures 10-7 and 10-8. The following provides a set of observations made as a result of the comparative analysis:

- **Human Health.** Figure 10-7 illustrates the time required following cleanup to reduce human health risk to below acceptable levels such that consumption advisories for recreational anglers can be removed. A general target has been established that these recreational advisories be removed within 10 years following cleanup. Each active remedy will satisfy this goal, based on noncancer risk, for action levels of 125 and 250 ppb. Based on cancer risk, this goal is not achieved with the minimum time of 15 years to reach protective levels at the 125 ppb action level. The largest reduction in time to reach protective levels is observed between 5,000 and 1,000 ppb action levels for cancer risk and noncancer risk. Figure 10-9 illustrates the time required following cleanup to reduce human health risk to below acceptable levels such that consumption advisories for high-intake fish consumers can be removed. A general target has been established that these advisories be removed within 30 years following cleanup. Active remedies achieve the cancer risk target at the 125 and 250 ppb action levels and for the 125 through 1,000 ppb action levels for noncancer risk.

- **Ecological Health.** Figure 10-7 also illustrates the time required to meet ecologically protective levels. Protective levels will not be reached within the modeled time frame (100 years) with no active remedy (Alternatives A and B). Active remedies will meet protective levels within the 30-year target time frame for action levels 125 through 1,000 ppb based on carnivorous bird deformity. Based on the piscivorous mammal, the target will be achieved for the 125 and 250 ppb action levels while marginally above the target for the 500 ppb action level (34 years).

  Figure 10-7 illustrates the time to meet ecologically protective levels based on surface water quality. A general target has been established that safe ecological levels should be met within 30 years following cleanup. Active remedies achieve this target for the 125 ppb action level and are marginally above the target for the 250 ppb action level (40 years).

- **Implementation Duration.** Figure 10-8 illustrates the implementation duration for each alternative at each action level. A general target has been set to perform the cleanup within a 10-year period. All of the alternatives satisfy this target at each action level with Alternative C2 having the shortest duration.

- **PCB Mass Removed.** Figure 10-8 illustrates that removal alternatives (Alternatives C1 through E) remove the same PCB mass at each action level, while capping (Alternative F) removes slightly less PCB mass. The 5,000 ppb action level removes 94 percent of the PCB mass in this reach, while any further decrease in the action level does not significantly increase the PCB mass removed. For Alternatives C1 through E, the mass removed varies from 24,950 kg at 5,000 ppb to 26,581 kg at 250 ppb.

- **Total Cost.** The total cost to implement an active remedy represents a 20- to 85-fold cost increase over the MNR alternative (Alternative B), estimated at $9.9 million. It can be seen on Figure 10-8 that dredging directly to a combined NR 213/NR 500 dewatering and disposal facility (Alternative C2A) is the lowest cost. Alternative C2A is also the least sensitive to changes in action level (Table 10-2). Other dredging and capping alternatives are incrementally more expensive, with Alternative C1 being the most expensive. For example, at the 1,000 ppb action level, Alternative C2A is estimated to be the least-cost approach at $174 million, with Alternative F at $357 million, and Alternative D at $505 million. Alternative E is estimated at $355 million, Alternative C2B is estimated at $492 million, Alternative C3 is estimated at $514 million, and Alternative C1 is estimated to cost $660 million .

- **Cost Effectiveness.** In order to evaluate the cost effectiveness of each alternative at each action level, the incremental cost per year reduction in time to remove fish consumption advisories (for recreational anglers) relative to the MNR alternative (Alternative B) was calculated using the cancer risk data. Due to the uniformity in the time to remove fish consumption advisories, these data are closely aligned to the total cost data. Dredging (Alternative C2A) is the most cost-effective remedy, and 125 and 250 ppb are the most cost-effective PCB action levels that meet protective thresholds.

10.7 Comparative Analysis of Alternatives - Green Bay, All Zones

The comparative analysis of alternatives for Green Bay Zone 2 (Table 8-10 and Figure 10-9), Green Bay Zone 3A (Table 8-11 and Figure 10-10), and Green Bay Zone 3B (Table 8-12 and Figure 10-11) show that regardless of the action taken in the Lower Fox River (excluding no action), there is very little effect (measured as reduced risk) on Green Bay for the human health and ecological scenarios considered. The following discussion provides a set of observations resulting from the comparative analysis:

- **Human Health.** Tables 8-10 through 8-13 illustrate the time required following cleanup in Green Bay to reduce human health risk to below acceptable levels such that consumption advisories for recreational anglers can be removed. A general target has been established that these recreational advisories be removed within 10 years following cleanup. None of the Green Bay active remedies will satisfy this goal. Removal actions conducted in Zone 3B (Alternatives D and G) will reduce the expected time frame to reach protective levels to 99 years for a Fox River action level of 500, 250, or 125 ppb.

- **Ecological Health.** Tables 8-10 through 8-13 also illustrate the time required to meet ecologically protective levels. A general target has been established that these protective ecological levels will be reached within 30 years following cleanup (a total of 40 years). None of the Green Bay active remedies will satisfy this goal for the ecological scenarios considered.

- **Implementation Duration.** Figures 10-9, 10-10, and 10-11 illustrate the implementation duration for each alternative at each action level. A general target has been set to perform the cleanup within a 10-year period. Most of the alternatives satisfy this target. In Green Bay Zone 2, removal to the 1,000 ppb action level will take five times longer than the next highest action level of 5,000 ppb. In Green Bay Zone 3B, the time required to remove sediment to the 500 ppb action level requires slightly more than 10 years, but equipment size and quantity can be modified during the remedial design to complete removal actions within the targeted time frame of 10 years.

- **PCB Mass Removed.** Figures 10-9, 10-10, and 10-11 illustrate that removal alternatives (Alternatives C, D, and G) remove the same PCB

mass at each action level. In Green Bay Zone 2, sediment removal to the 1,000 ppb action level removes six times as much PCB mass as the next highest action level of 5,000 ppb (basically there is not much mass above the 5,000 ppb action level). In Green Bay Zone 3A, significantly more PCB mass is removed at the 500 ppb action level as compared with the 1,000 ppb action level. Only one action level is carried forward for Green Bay Zone 3B.

- **Total Cost.** The total cost to implement an active remedy represents a 100-fold to 1,200-fold cost increase over the MNR alternative (Alternative B), estimated at $9.9 million (Table 10-3). It can be seen on Figures 10-9, 10-10, and 10-11 that dredging directly to a CAD site (Alternative G) is the lowest cost active alternative.

- **Cost Effectiveness.** As discussed above, human health and ecologically protective levels are generally not achieved for Green Bay within the modeled time frame. As a result, it was not possible to perform calculations regarding cost-effectiveness.

10.8 Comparative Analysis of Action Levels on a System-wide Basis

The FS and associated modeling efforts have focused on evaluating system-wide action levels; however, as can be seen from the projections, the same action level provides markedly different degrees of RAO achievement. In order to facilitate future decision-making processes and the inherent trade-offs between cleanup cost and achieving RAOs, this section provides the tools that will be necessary during future decision-making efforts for the entire system. Future modeling efforts may be required to fully evaluate the effect of different action levels for each reach or zone, but the following discussion provides a rationale for focusing those modeling efforts.

Figures 10-12 and 10-13 compare the time to achieve protective levels for human health and ecological receptors for all four river reaches. General targets have been established that: 1) recreational fish consumption advisories be removed within 10 years following cleanup; 2) high-intake fish consumption advisories be removed within 30 years following cleanup; and 3) that achievement of safe ecological levels occurs within 30 years. For the MNR alternative, these thresholds are expected to be met in 20 years and 40 years, respectively.

Based on the 100-year modeled projections illustrated on Figures 10-12 and 10-13, it appears that the Appleton to Little Rapids Reach will likely show some reduced risk by natural recovery processes when compared to other river reaches; the Little Lake Butte des Morts Reach will show less improvement without an active remedy. However, neither of these reaches will meet protective levels in the targeted time frame without an active remedy. The other two reaches, Little Rapids to De Pere Reach and De Pere to Green Bay Reach, will not show appreciable improvement (reduced risk) by monitored natural recovery processes alone. Physical site conditions such as: the quantity and volume of PCB mass present in these reaches, the size of the reach, vessel traffic, storm events, and hydraulic exchange of water flow with Green Bay contribute to the long-term fate of contaminants that limit the long-term effectiveness of natural recovery processes. As shown on Figure 10-12, the action levels required to satisfy the targeted time frame of 10 years following remediation include: 1,000 ppb in Little Lake Butte des Morts, 250 ppb in Appleton to Little Rapids, and 125 ppb in Little Rapids to De Pere. The De Pere to Green Bay Reach will not achieve protective levels for 15 years at the 125 ppb action level. The time to reach protective levels would be 7 to 15 years for each of the aforementioned river reaches. At these same action levels, the time to reach ecologically protective levels based on the piscivorous mammal would be approximately 29, 18, 15, and 18 years, respectively. The protectiveness of these action levels would have to be verified by modeling specifically for this selected group of action levels.

The objective of RAO 4 is to reduce PCB sediment loading to Green Bay and ultimately Lake Michigan. Figure 10-14 illustrates the modeled sediment loading to Green Bay for each Fox River action level. These data indicate that the largest decrease occurs between the no action and 5,000 ppb action level. There is also a substantial decrease between the 5,000 and 1,000 ppb actions levels, but only marginal reductions thereafter. A general target has been established to reduce PCB sediment loading to Green Bay from Fox River to below the PCB sediment loading contributed to Green Bay by all other tributaries combined (10 kg/year). This target is achieved immediately following cleanup for the 125, 250, and 500 ppb action levels. For the 1,000 ppb action level, the target level is achieved in 4 years and it is also achieved in 24 years for the 5,000 ppb action level. The target PCB loading to Green Bay is not achieved for the no action approach in Fox River. The PCB loading to Green Bay from the Fox River also drops below the upstream loading contributed by Lake Winnebago (18 kg/year) in less than 24 years for all action levels, except that this level is never achieved using the No Action alternative.

10.9 Comparative Analysis Summary

In summary, this FS does not select the "best" remedial alternative and action level for implementation in the Lower Fox River and Green Bay. Final selection of a remedial alternative and action level will depend on several decision-making factors including long-term land use restrictions, community support, residual risks, and implementation factors discussed in Sections 8 and 9 of the FS. However, the comparative analysis does present the relative performance of each alternative and related action level relative to each criterion. This analysis summarizes key highlights of these comparisons. For example, the largest reductions in time to reach protective levels for a particular PCB action level relative to the next highest action level and the most cost-effective action level relative to the number of years required to remove recreational fish consumption advisories are described below. Key findings for each reach and zone are summarized below.

- **Little Lake Butte des Morts Reach**

  - At a minimum, the 1,000 ppb PCB action level will be required to meet protective human health and ecological thresholds in 10 and 30 years after remedy completion. The 5,000 ppb action level will not meet protective thresholds in this time frame.

  - Ecologically protective surface water concentrations are achieved within the 30-year target for the 125 and 250 ppb action levels.

  - Most of the PCB mass is removed at the 1,000 ppb action level (93%). Only 7 percent of the PCB mass is contained in the combined action levels of 125, 250, and 500 ppb.

  - The Dredge and Off-site Disposal, Thermal Treatment, and Dredge to CDF alternatives (Alternatives C2, E, and D) at the 1,000 ppb action level are the lowest cost alternatives relative to the time required to remove recreational fish consumption advisories.

- **Appleton to Little Rapids Reach**

  - At a minimum, the 500 ppb PCB action level will be required to meet protective human health and ecological thresholds in 30 years after remedy completion. The 250 ppb action level will be required to meet the 10-year time frame. The 1,000 and 5,000

ppb action levels will not meet protective thresholds in this time frame.

- Ecologically protective surface water concentrations are achieved within the 30-year target for the 125 and 250 ppb action levels. The 500 ppb action level is marginally above the target at about 40 years.

- The bulk of PCB mass is removed at the 1,000 ppb action level (87%). The remaining PCB mass (13%) is contained in the combined 125, 250, and 500 ppb action levels.

- The Thermal Treatment alternative (Alternative E) at the 1,000 ppb PCB action level is the lowest cost alternative relative to the time required to remove recreational fish consumption advisories.

- **Little Rapids to De Pere Reach**

  - At a minimum, the 500 ppb PCB action level will be required to meet protective human health and ecological thresholds in 30 years after remedy completion. The 125 ppb action level is required to meet the 10-year time frame. The 5,000 and 1,000 ppb action levels will not meet protective thresholds in this time frame.

  - Ecologically protective surface water concentrations are achieved within the 30-year target for the 125 ppb action level. The 250 ppb action level is marginally above the target at about 40 years.

  - The bulk of PCB mass is removed at the 1,000 ppb action level (92%). Most of the remaining PCB mass (8%) is below the 250 ppb action level (99%).

  - The Dredge and Off-site Disposal at a Combined NR 213/NR 500 Dewatering and Disposal Facility alternative (Alternative C2A), the Dredge to CDF alternative (Alternative D), Thermal Treatment alternative (Alternative E), and Capping alternative (Alternative F) at the three lowest PCB action levels (125, 250, and 500 ppb) are the lowest cost alternatives relative to the time required to remove recreational fish consumption advisories.

- **De Pere to Green Bay Reach**

  - At a minimum, the 250 ppb PCB action level will be required to meet protective human health and ecological thresholds in 30 years after remedy completion. The no action level will meet the 10-year time frame. The 5,000 and 1,000 ppb action levels will not meet protective thresholds in this time frame.

  - Ecologically protective surface water concentrations are achieved within the 30-year target for the 125 ppb action level.

  - The bulk of PCB mass is removed at the 5,000 ppb action level (94%). The remaining PCB mass (6%) is below the 1,000 ppb action level (99%).

  - The Dredge and Off-site Disposal at a Combined NR 213/NR 500 Dewatering and Disposal Facility alternative (Alternative C2A), the Dredge and CDF alternative (Alternative D), the Thermal Treatment alternative (Alternative E), and the Capping alternative (Alternative F) at the three lowest PCB action levels (125, 250, and 500 ppb) are the lowest cost alternatives relative to the time required to remove recreational fish consumption advisories.

  - PCB sediment loading to Green Bay from all the Lower Fox River reaches achieves the target of 10 kg/yr within a reasonable time frame (24 years or less) for all action levels, except the No Action alternative which does not achieve the target within the modeled time frame.

- **Green Bay, All Zones**

  - None of the action levels implemented in the Lower Fox River shows a decrease in long-term fish tissue concentrations in Green Bay. The lower action levels (125, 250, 500, and 1,000 ppb of the Lower Fox River) do not significantly change the outcome of Green Bay fish tissue concentrations. As discussed in Section 8, this is partly because the majority of PCB mass is removed at the 1,000 ppb action level in Green Bay.

- None of the PCB action levels implemented in Green Bay will meet protective human health and ecological thresholds in 30 years after remedy completion. In Green Bay Zone 3B, removal to the 500 ppb action level will show a reduction in the number of years required to meet protective levels, but not within the targeted time frame.

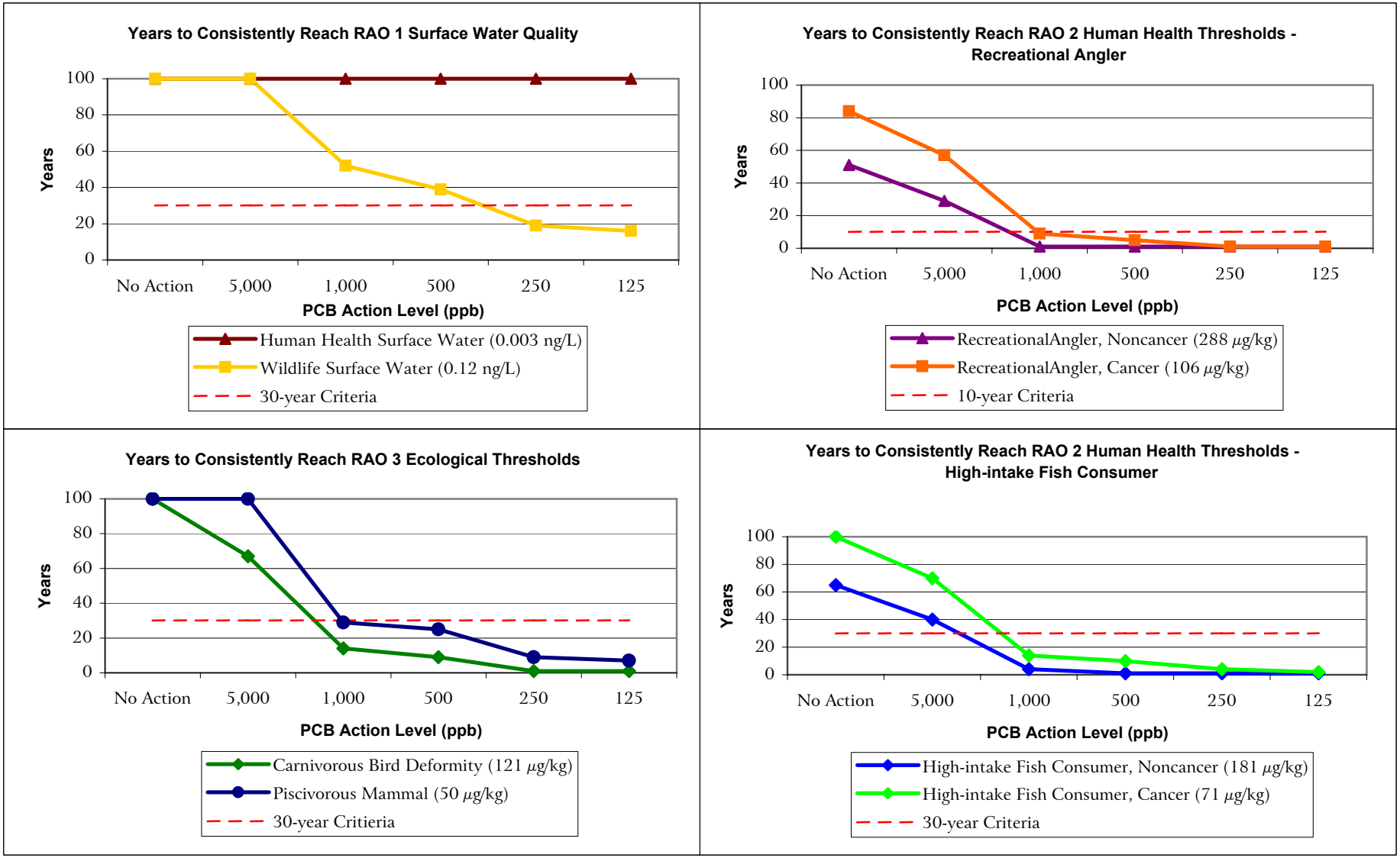
- The bulk of PCB mass is removed at the 1,000 ppb action level (95%) for Green Bay Zone 2. The remaining PCB mass (5%) is incrementally contained in the lower action levels (125, 250, and 500 ppb). The bulk of PCB mass is removed at the 125 ppb action level (100%) for Green Bay zones 3 and 4. Less than 15 and 30 percent of the PCB mass would be removed at the 500 ppb action level in Green Bay zones 3A and 3B, respectively. The large volume of sediments in Green Bay coupled with the relatively low levels of PCB concentrations indicates that a large quantity of PCB mass resides in Green Bay. However, this PCB mass is widely distributed and dispersed in Green Bay at relatively low concentrations.

10.10 Section 10 Figures and Tables

Figures and tables for Section 10 follow page 10-22 and include:

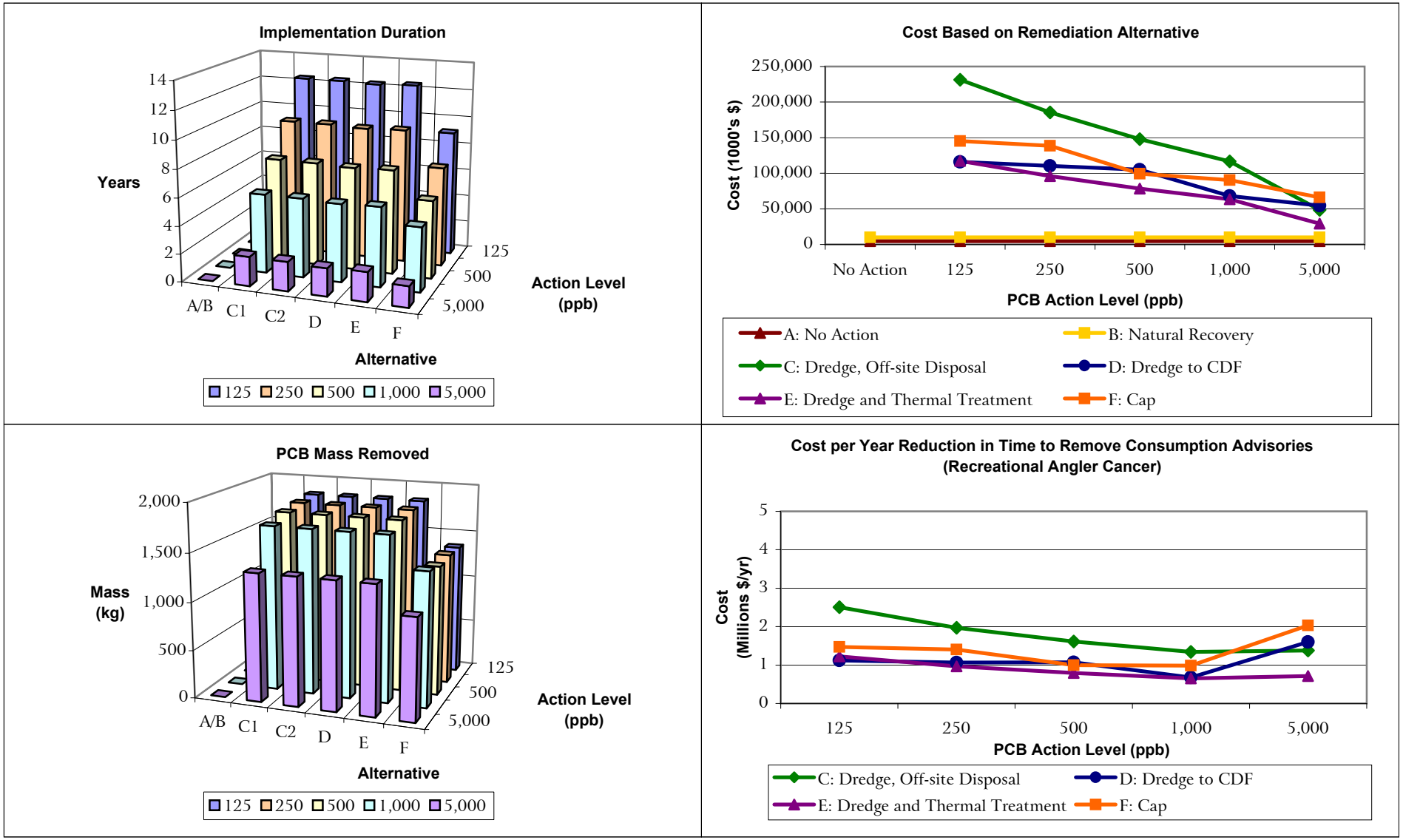
Figure 10-1 Comparison of Human Health and Ecological Protectiveness - Little Lake Butte des Morts to Appleton Reach
Figure 10-2 Comparison of Cleanup Duration, Mass Removal, and Cost - Little Lake Butte des Morts
Figure 10-3 Comparison of Human Health and Ecological Protectiveness - Appleton to Little Rapids Reach
Figure 10-4 Comparison of Cleanup Duration, Mass Removal, and Cost - Appleton to Little Rapids Reach
Figure 10-5 Comparison of Human Health and Ecological Protectiveness - Little Rapids to De Pere Reach
Figure 10-6 Comparison of Cleanup Duration, Mass Removal, and Cost - Little Rapids to De Pere Reach
Figure 10-7 Comparison of Human Health and Ecological Protectiveness - De Pere to Green Bay Reach
Figure 10-8 Comparison of Cleanup Duration, Mass Removed, and Cost - De Pere to Green Bay Reach (Green Bay Zone 1)
Figure 10-9 Comparison of Cleanup Duration, Mass Removal, and Cost - Green Bay Zone 2

Figure 10-1 Comparison of Human Health and Ecological Protectiveness - Little Lake Butte des Morts to Appleton Reach



Note: Remedial alternatives C, D, E, and F have the same risk reduction when compared across the same action levels. Therefore, the different remedial alternatives are not displayed separately on the risk reduction graphs (except No Action).

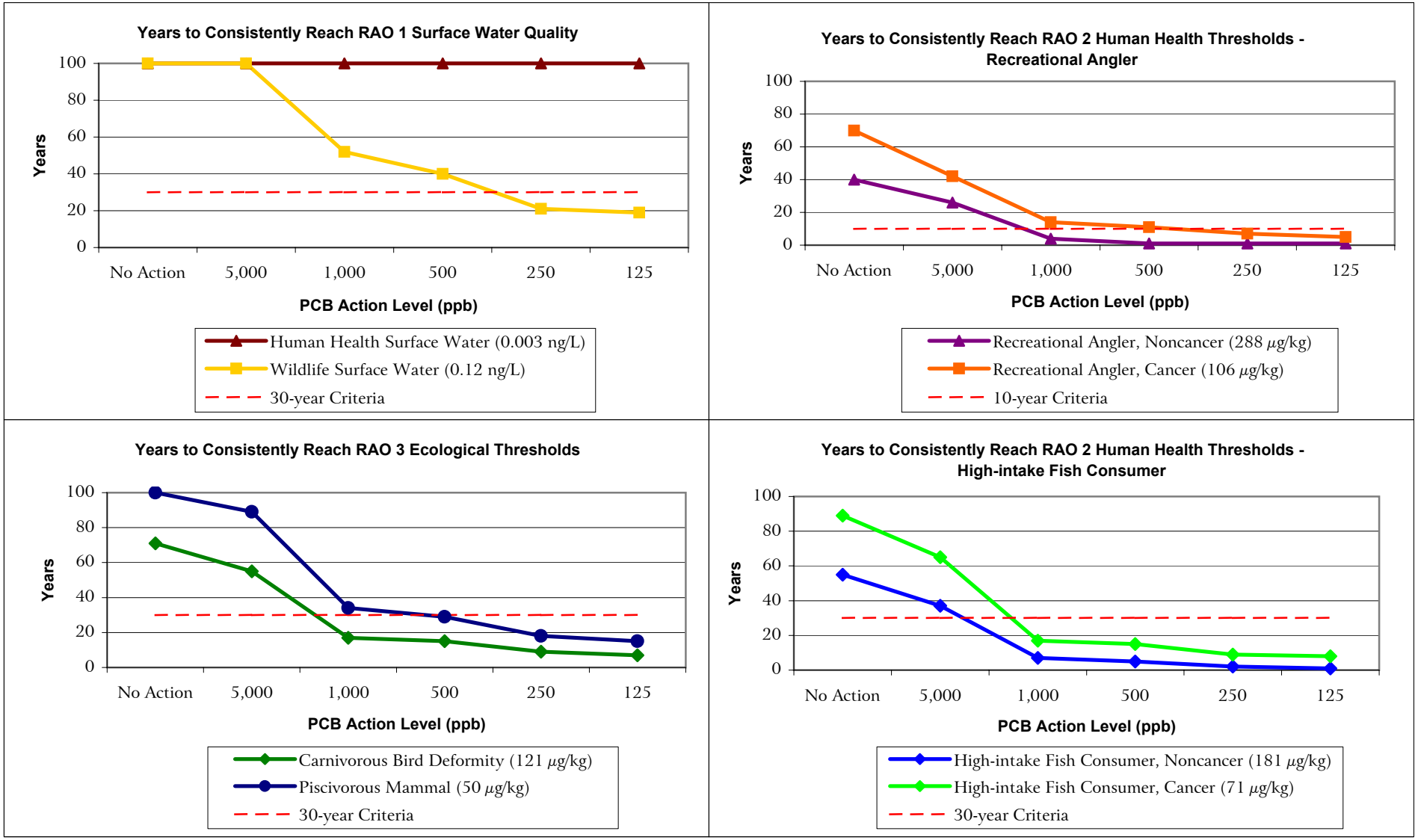
Figure 10-2 Comparison of Cleanup Duration, Mass Removal, and Cost - Little Lake Butte des Morts



Note: 20% contingency costs not included. Alternative C1 costs used.

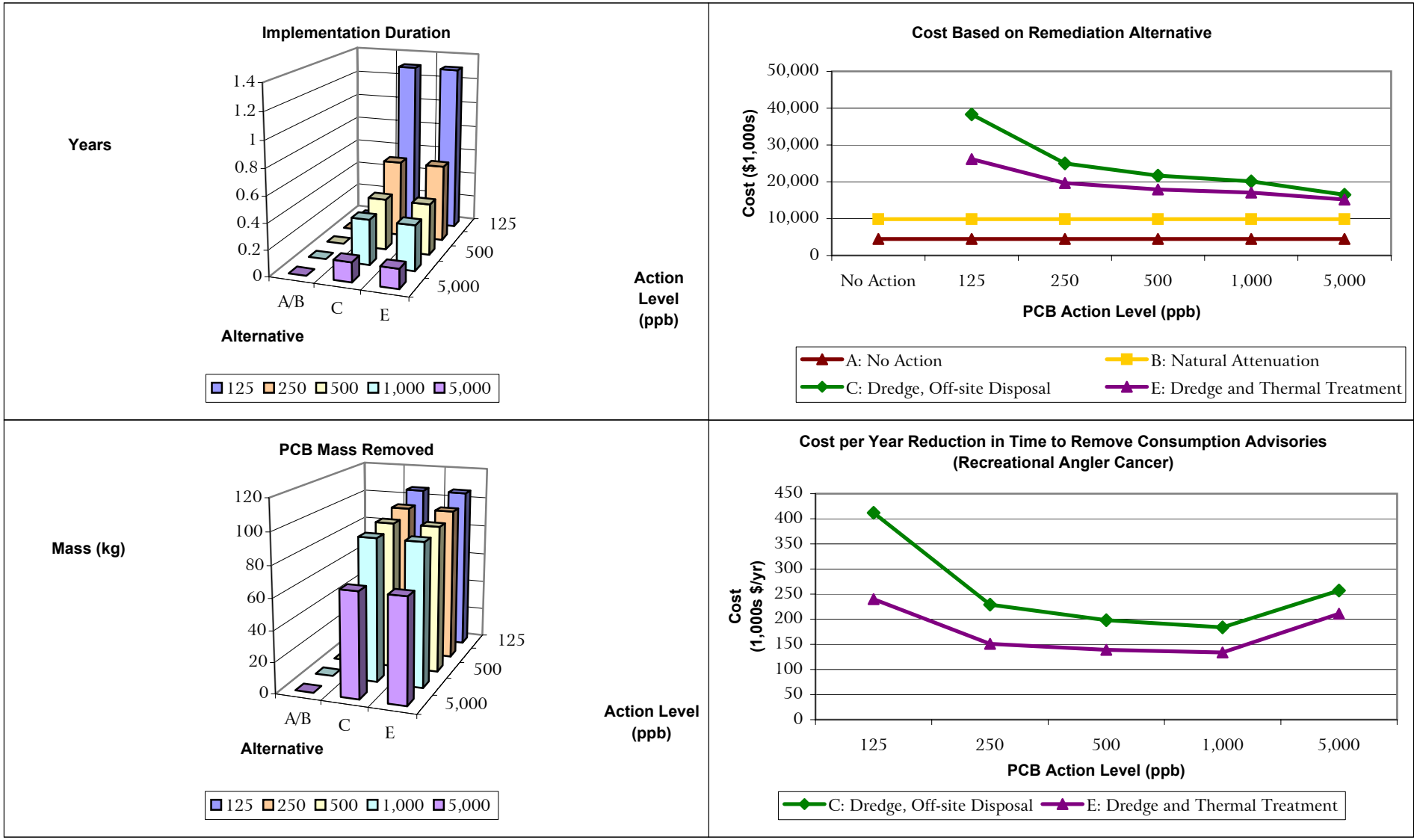
"Cost per year" is the calculated additional cost per year for implementing any action level other than MNR. $\left[\frac{Cost\ Alt\ x - Cost\ Alt\ B}{Time\ B - Time\ x}\right]$

Figure 10-3 Comparison of Human Health and Ecological Protectiveness - Appleton to Little Rapids Reach



Note: Remedial alternatives C, D, E, and F have the same risk reduction when compared across the same action levels. Therefore, the different remedial alternatives are not displayed separately on the risk reduction graphs (except No Action).

Figure 10-4 Comparison of Cleanup Duration, Mass Removal, and Cost - Appleton to Little Rapids Reach



Note: 20% contingency costs not included.

"Cost per year" is the calculated additional cost per year for implementing any action level other than MNR. $\left[\frac{Cost\ Alt\ x - Cost\ Alt\ B}{Time\ B - Time\ x}\right]$

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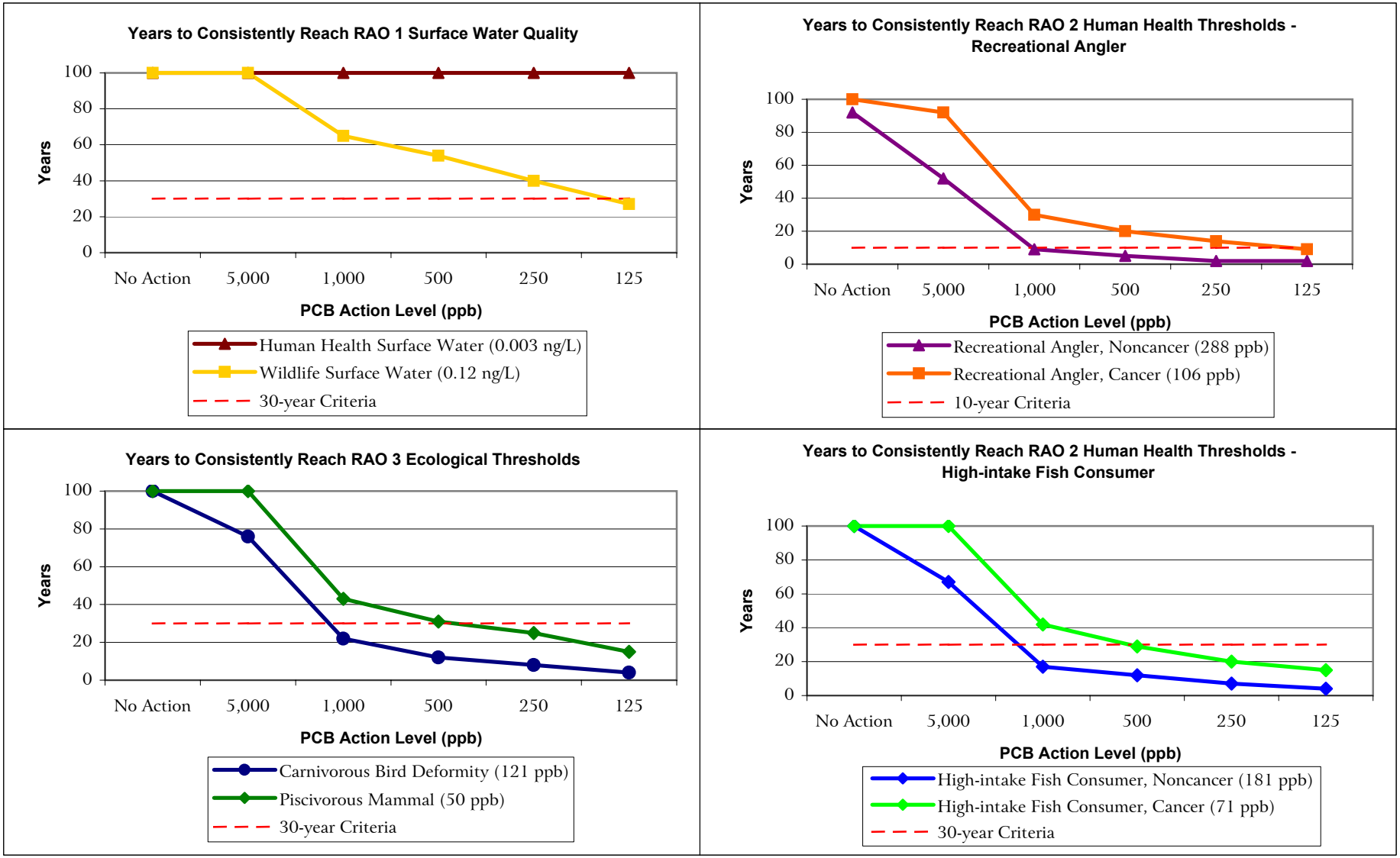
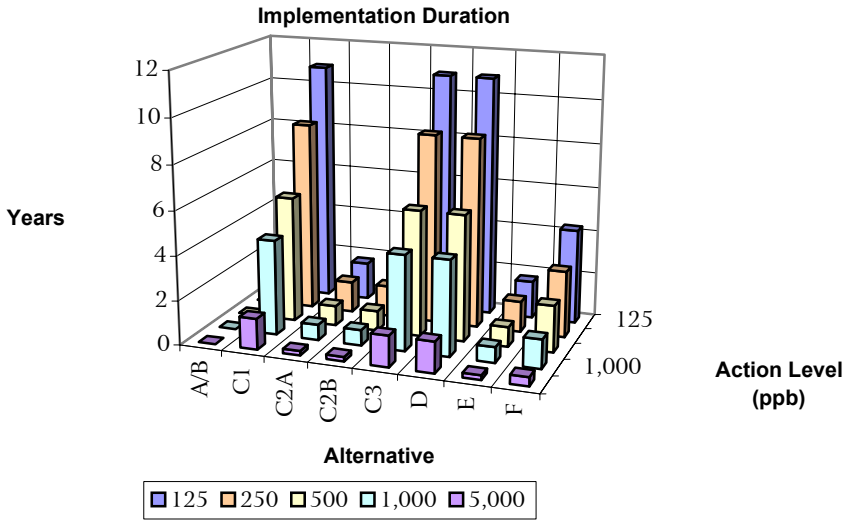
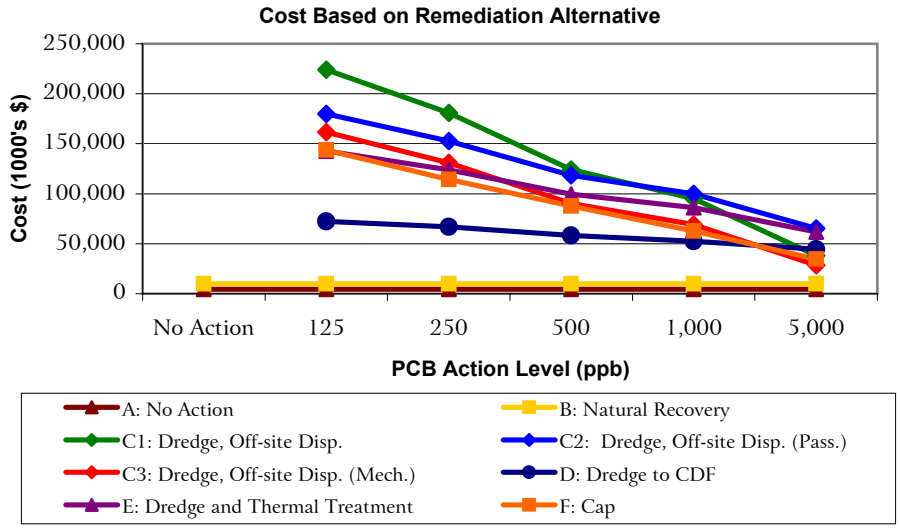
Figure 10-5 Comparison of Human Health and Ecological Protectiveness - Little Rapids to De Pere Reach

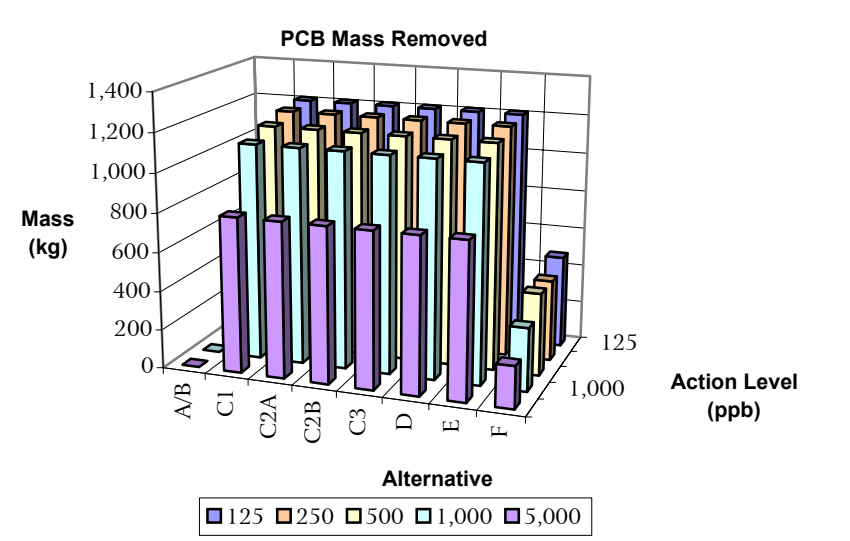


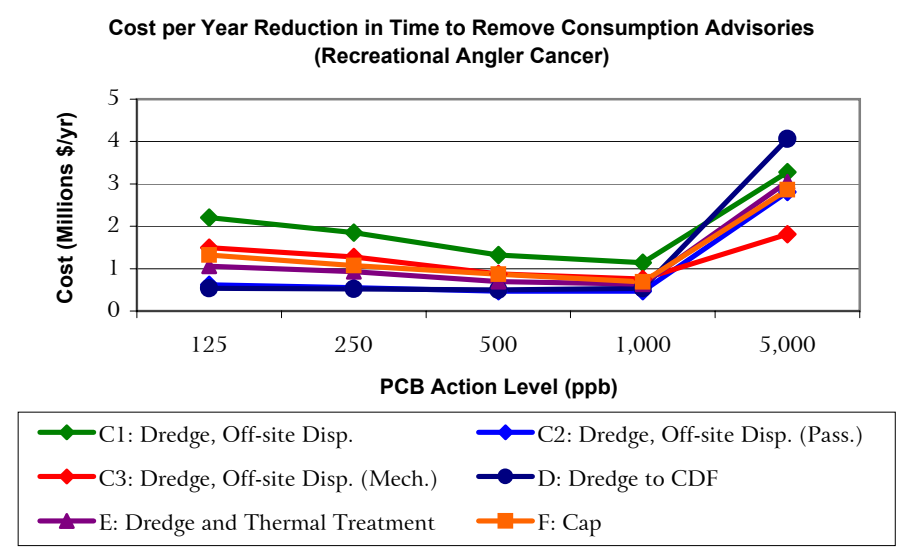
Note: Remedial alternatives C, D, E, and F have the same risk reduction when compared across the same action levels. Therefore, the different remedial alternatives are not displayed separately on the risk reduction graphs (except No Action).

Figure 10-6 Comparison of Cleanup Duration, Mass Removal, and Cost - Little Rapids to De Pere Reach





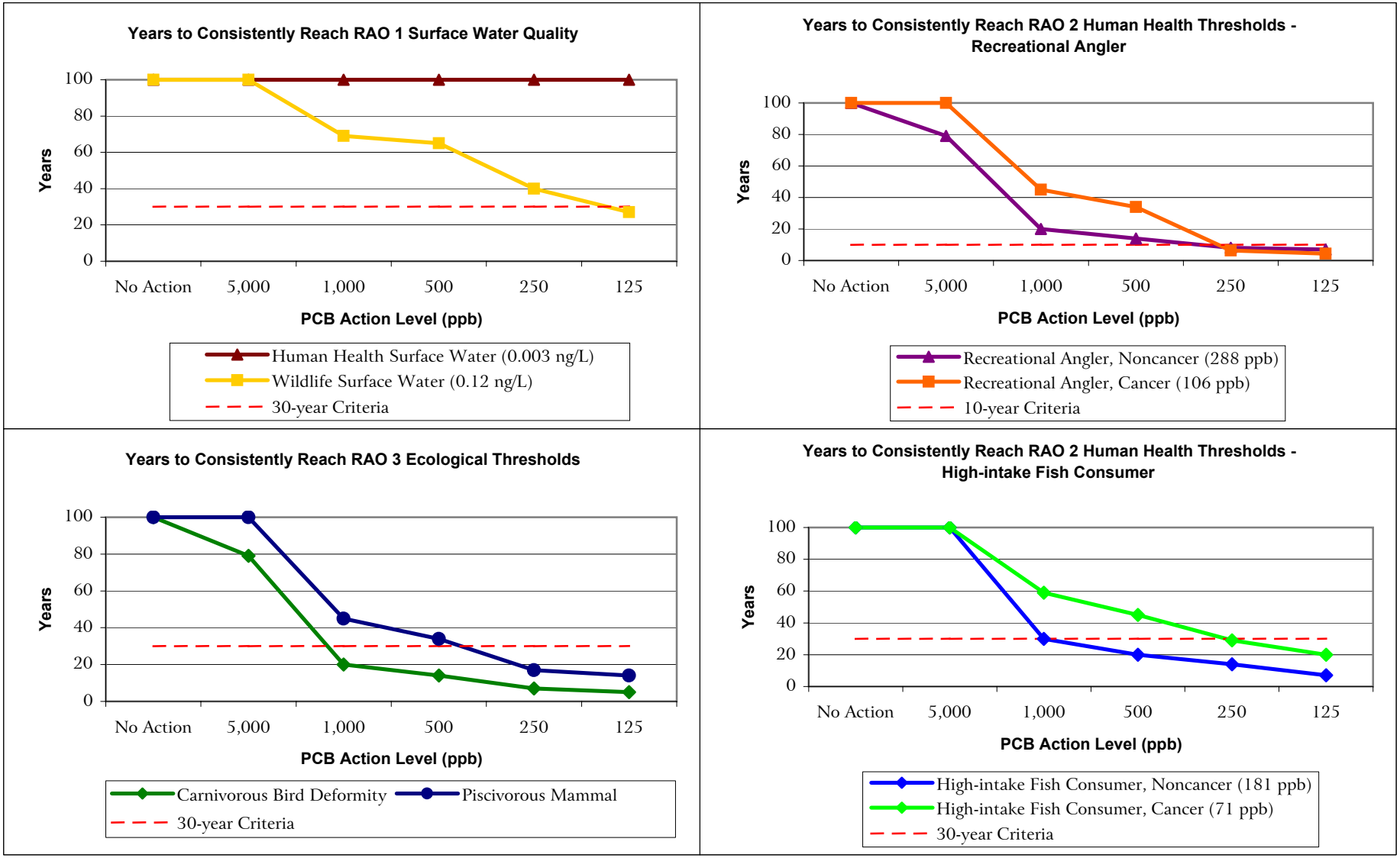




Note: 20% contingency costs not included. Alternative C2B costs used.

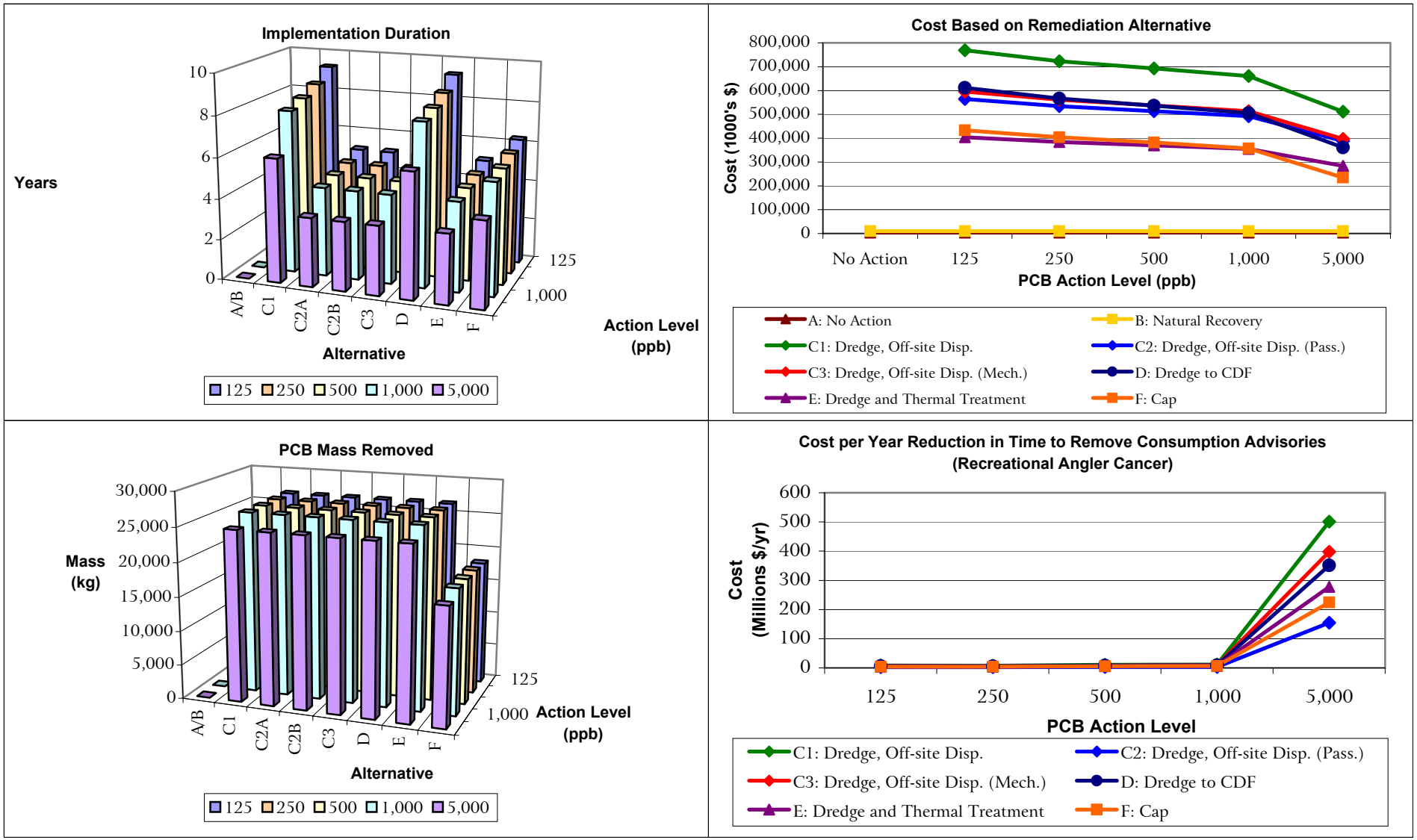
"Cost per year" is the calculated additional cost per year for implementing any action level other than MNR. $\left[\frac{Cost\ Alt\ x - Cost\ Alt\ B}{Time\ B - Time\ x}\right]$

Figure 10-7 Comparison of Human Health and Ecological Protectiveness - De Pere to Green Bay Reach



Note: Remedial alternatives C, D, E, and F have the same risk reduction when compared across the same action levels. Therefore, the different remedial alternatives are not displayed separately on the risk reduction graphs (except No Action).

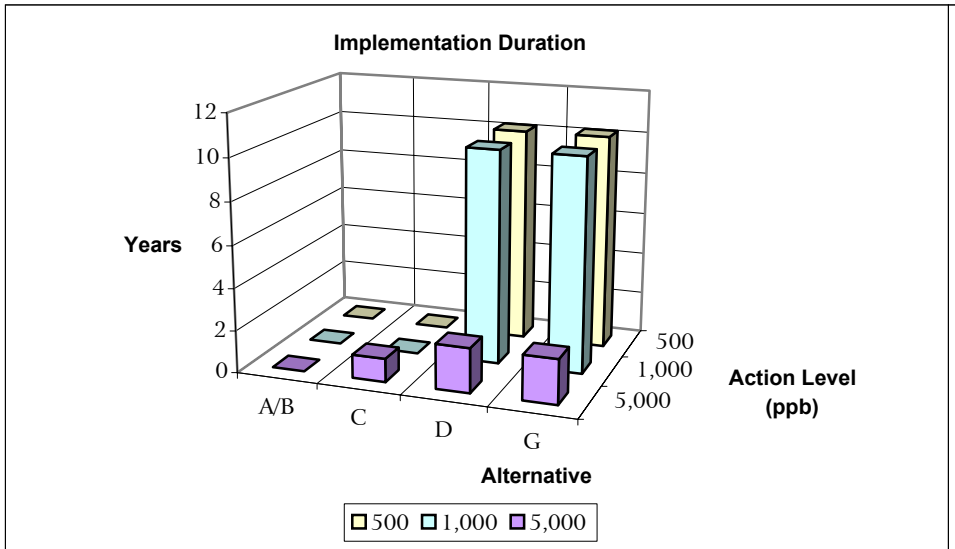
Figure 10-8 Comparison of Cleanup Duration, Mass Removal, and Cost - De Pere to Green Bay Reach (Green Bay Zone 1)

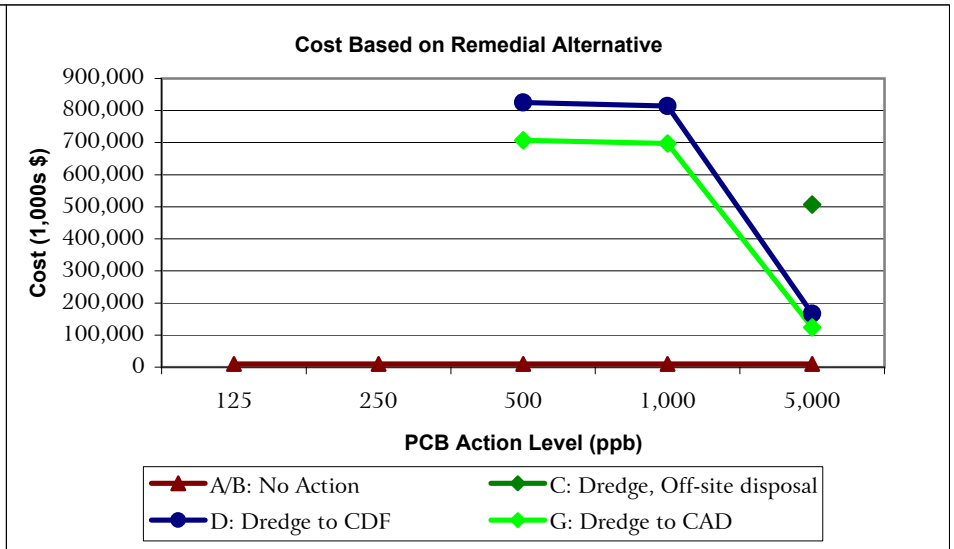


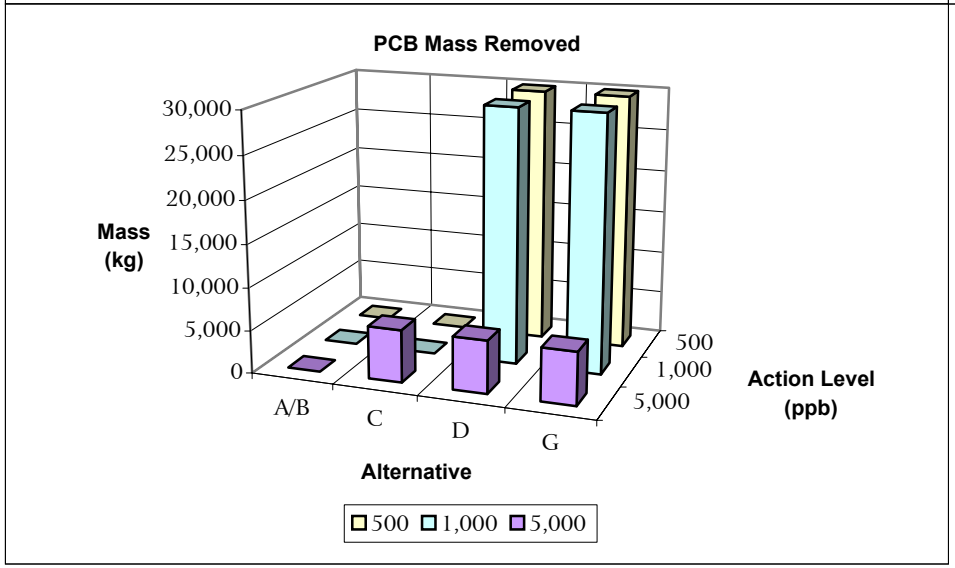
Note: 20% contingency costs not included. Alternative C2B costs used.

"Cost per year" is the calculated additional cost per year for implementing any action level other than MNR. $\left[\frac{Cost\ Alt\ x - Cost\ Alt\ B}{Time\ B - Time\ x}\right]$

Figure 10-9 Comparison of Cleanup Duration, Mass Removal, and Cost - Green Bay Zone 2



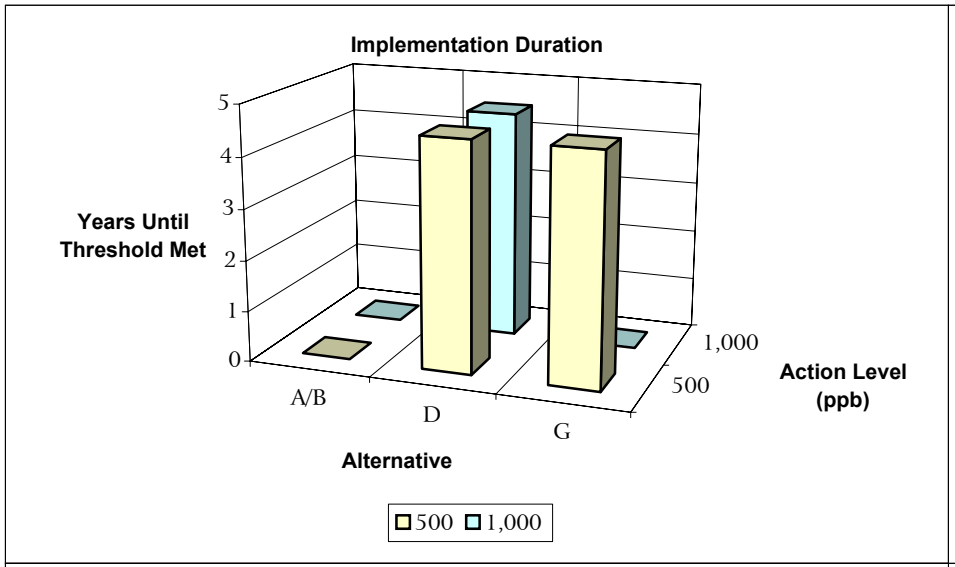


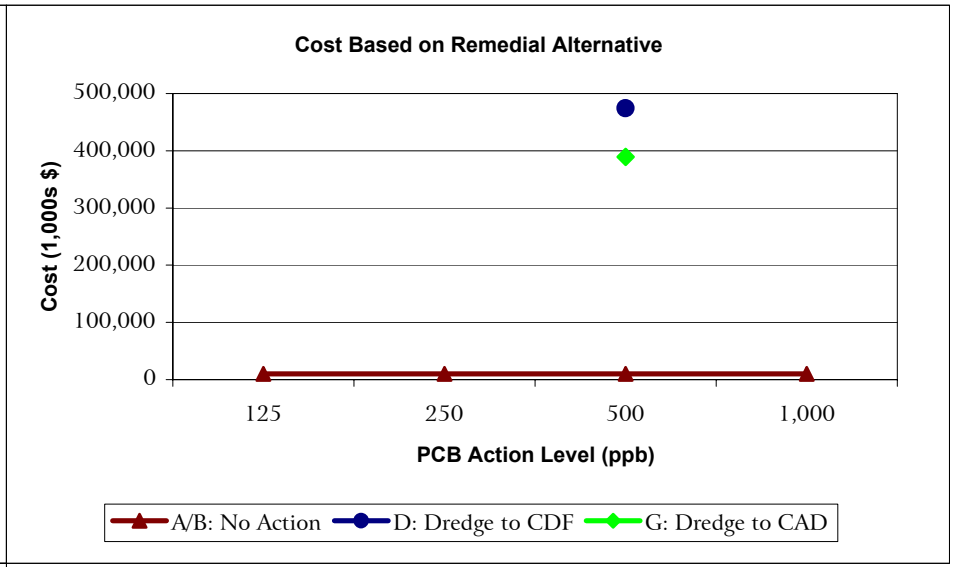


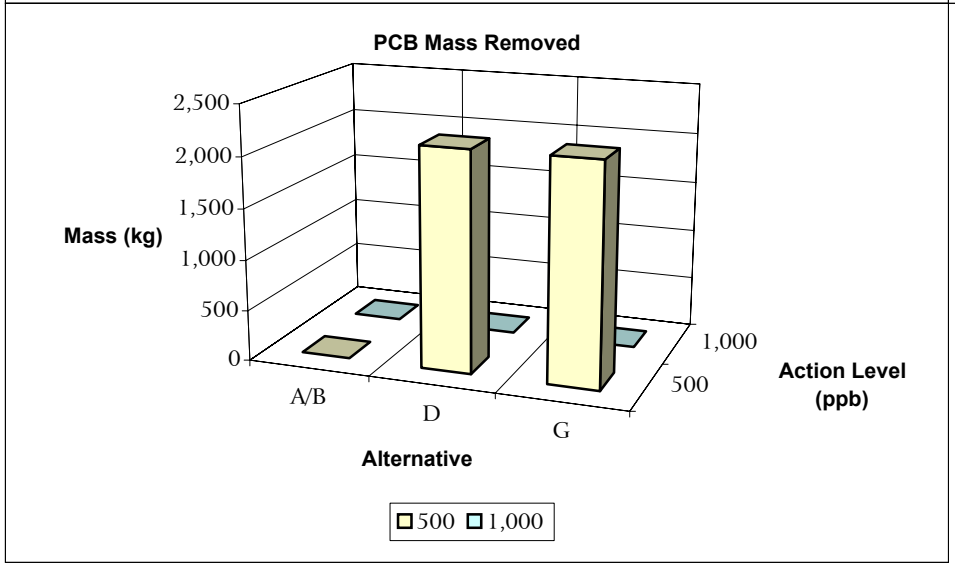
No Cost per year calculated due to thresholds never being met in 100 years.

Note: 20% contingency costs not included.

Figure 10-10 Comparison of Cleanup Duration, Mass Removal, and Cost - Green Bay Zone 3A



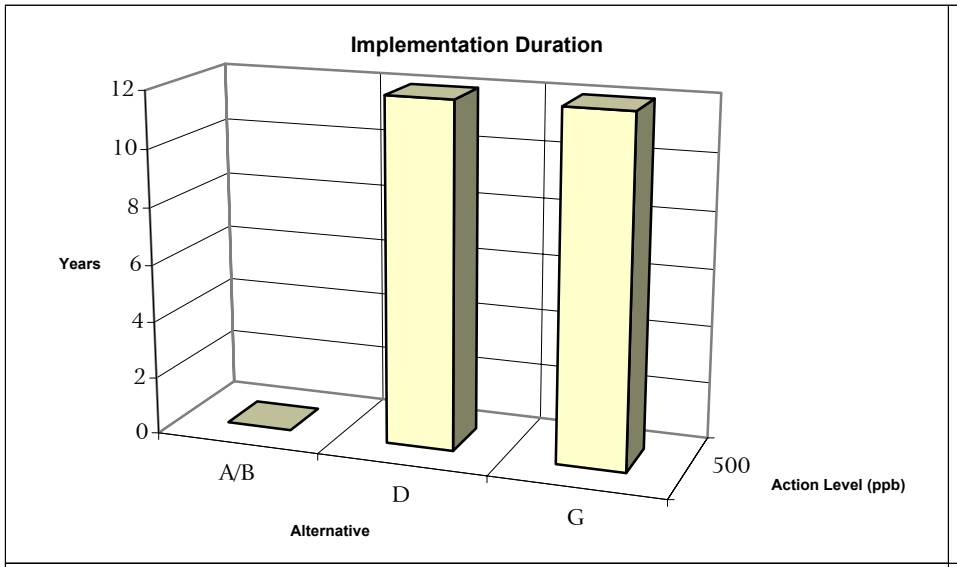


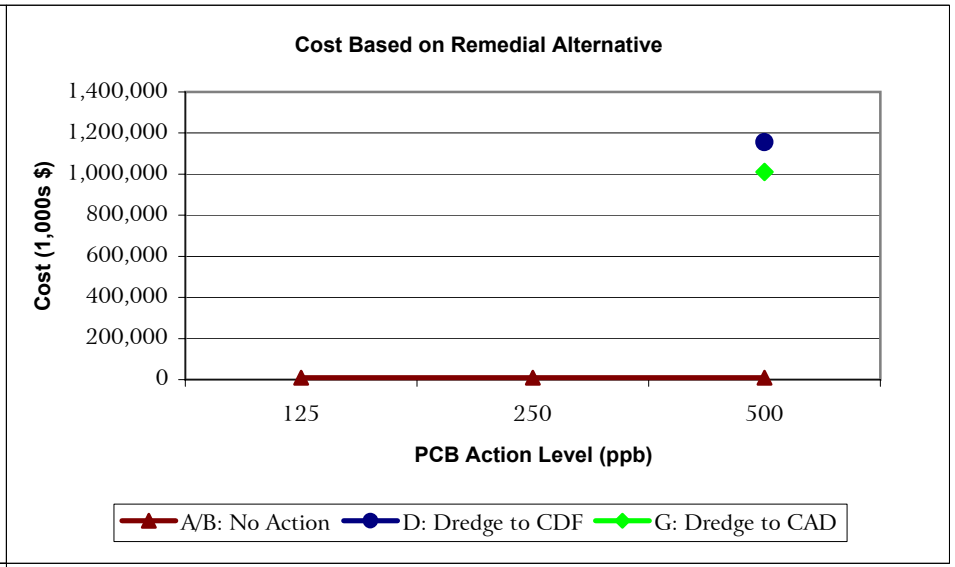


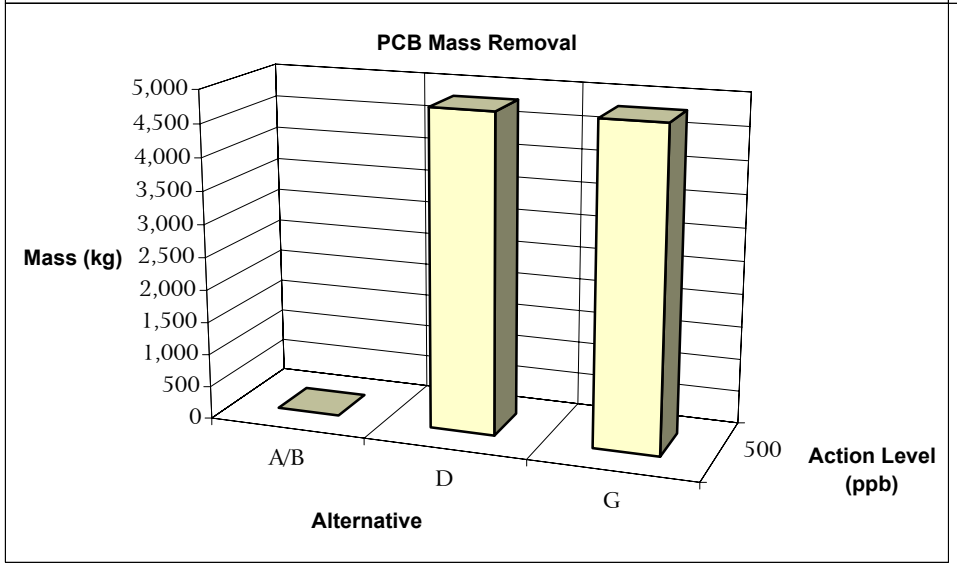
No Cost per year calculated due to thresholds never being met in 100 years.

Note: 20% contingency costs not included.

Figure 10-11 Comparison of Cleanup Duration, Mass Removal, and Cost - Green Bay Zone 3B







No Cost per year calculated due to thresholds never being met in 100 years.

Note: 20% contingency costs not included.

Figure 10-12 Comparison of Human Health Protectiveness - All Reaches

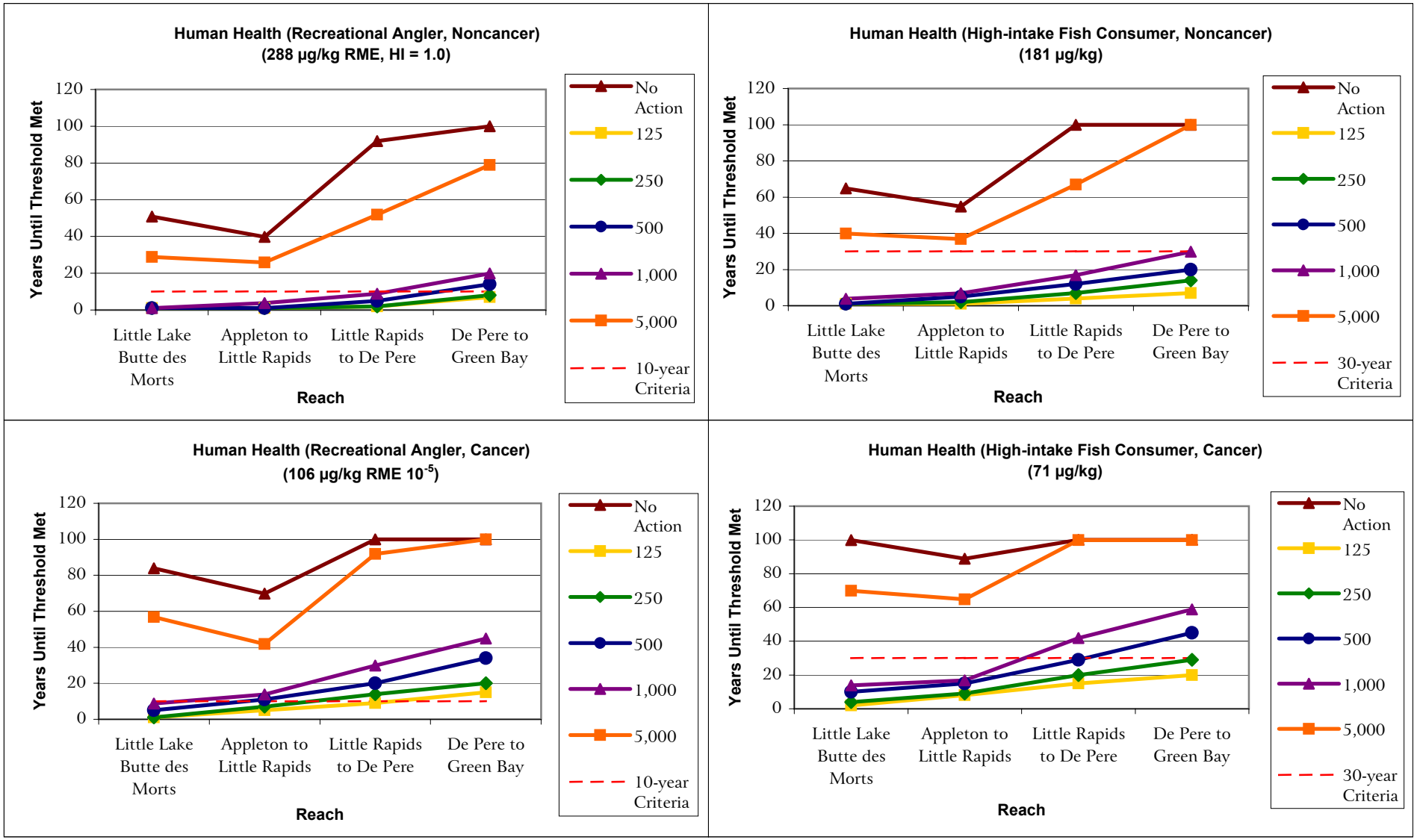
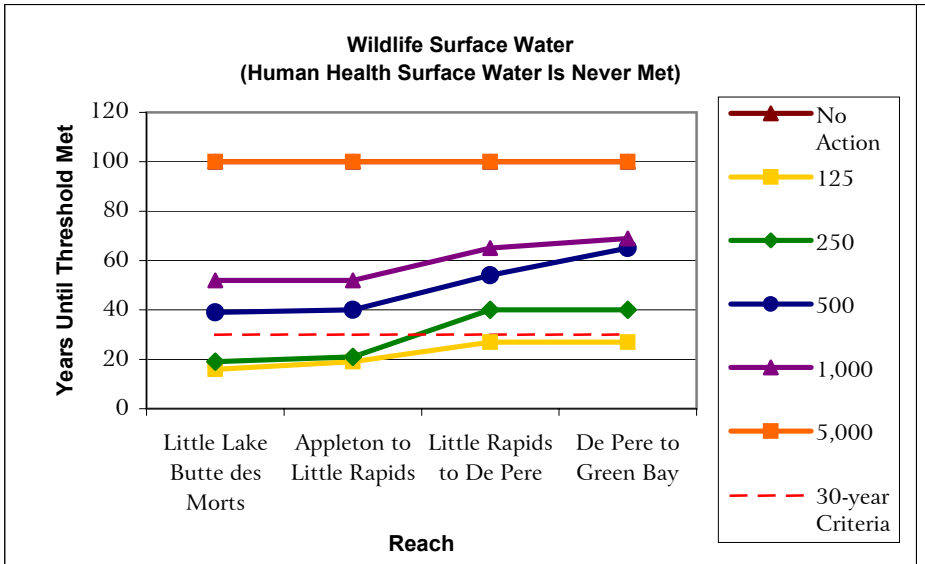
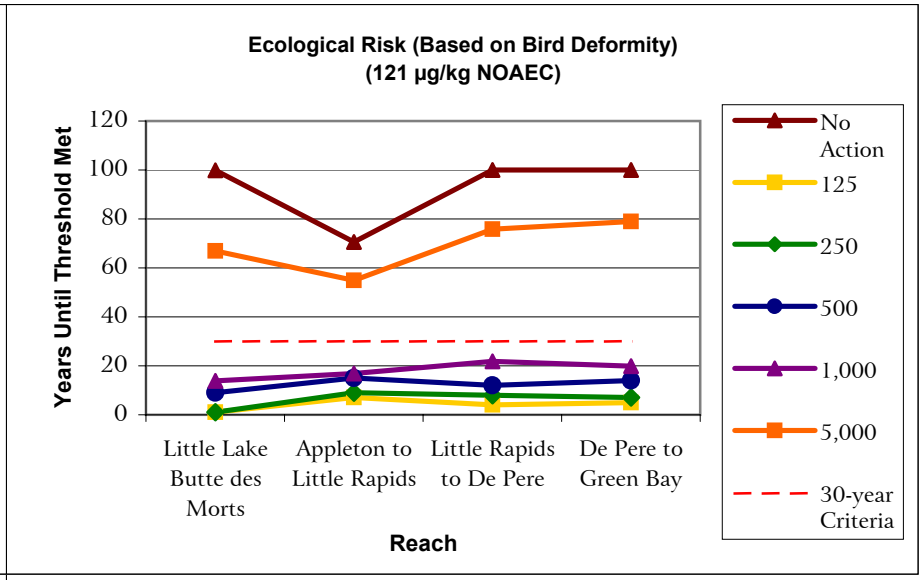
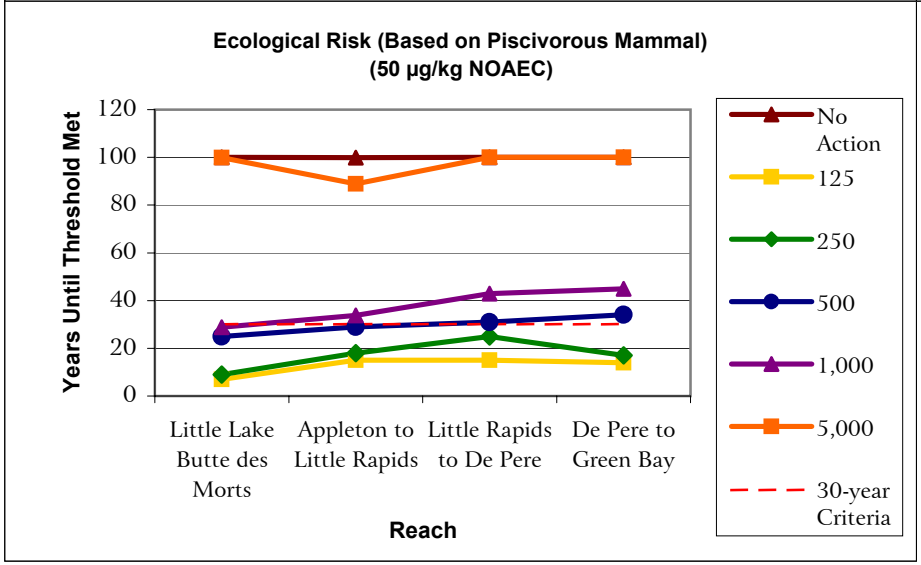


Figure 10-13 Comparison of Protection - All Reaches







RAO 4 not evaluated in Fox River reaches.

Figure 10-14 Total PCB Sediment Loading for All Remedial Action Levels - De Pere to Green Bay Reach

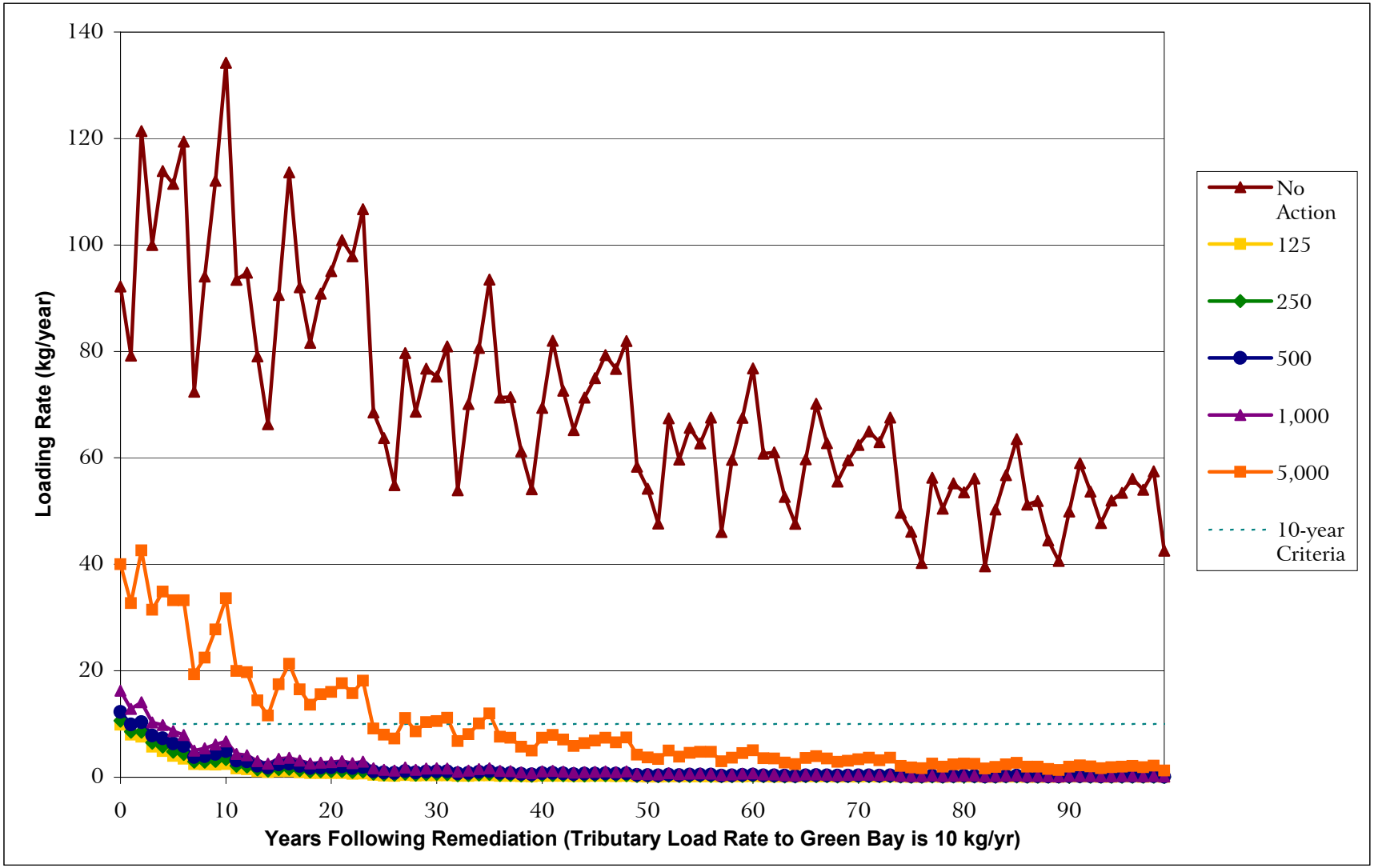


Table 10-1 Comparative Evaluation Measures

Issue	Quantitative Measure	Comment
Time Post-remediation Necessary to Achieve Fish Tissue Concentrations Resulting in Negligible Risk to Human Receptors	Number of years necessary to achieve the "human health - recreational fish consumer RME, HI is 1.0" for noncancer, walleye, whole fish consumption.	As discussed in Section 8, none of the remedial alternatives identified in the FS provide for immediate 100 percent relief for all human and ecological receptors in the river and bay. A key assumption in this alternative analysis is that sediment transport and burial over time would achieve further reductions in PCB mass and thus concomitant reductions in risk. At some time in the future, natural recovery processes would result in restoration of the river and bay to be fully protective for all uses and all receptors. Thus, the time to achieve such risk reduction is considered an objective measure of the efficacy of an alternative. Targeted time frame of 10 years following remediation.
	Number of years necessary to achieve the "human health - recreational fish consumer RME" for 10^{-5} cancer risk level, walleye, whole fish consumption.	As discussed in Section 8, the number of years required to reach protective levels were projected for 100 years from a calibration period of 6 years. There is no precision associated with these projections; however, they do provide reasonable expectations of trends between alternatives. Targeted time frame of 10 years following remediation.
	Number of years necessary to achieve the "human health - high-intake fish consumer RME" for 10^{-5} cancer risk level, walleye, whole fish consumption.	The targeted time frame to remove fish consumption advisories for high-intake fish consumers is 30 years following remediation.
	Number of years necessary to achieve the "human health - high-intake fish consumer RME, HI is 1.0" for noncancer walleye whole fish consumption	The targeted time frame to remove fish consumption advisories for high-intake fish consumers is 30 years following remediation.

Table 10-1 Comparative Evaluation Measures (Continued)

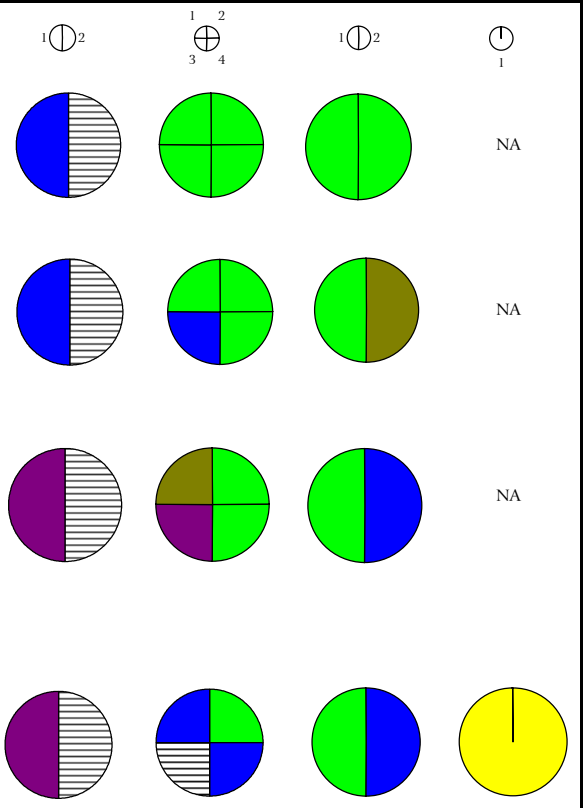
Issue	Quantitative Measure	Comment
Time Post-remediation Necessary to Achieve Fish Tissue Concentrations Resulting in Negligible Risk to Ecological Receptors	Number of years necessary to achieve the "ecological health - carnivorous bird deformity NOAEC" based on carp, whole fish consumption.	For the purposes of this FS, the targeted time frame to achieve ecological protectiveness is 30 years following remediation (or implementation of monitored natural recovery). The ecological thresholds are more stringent than the human health thresholds.
	Number of years necessary to achieve the "ecological health - piscivorous mammal NOAEC" based on carp, whole fish consumption.	For the purposes of this FS, the targeted time frame to achieve ecological protectiveness is 30 years following remediation (or implementation of monitored natural recovery). This ecological threshold is the most stringent threshold carried forward in the FS for comparative purposes.
Time to Meet Surface Water Quality Protective of Human and Ecological Receptors Based on Sediment PCB Concentrations	Number of years necessary to achieve surface water quality criteria - human health drinking water (0.0003 ng/L) and wildlife (0.12 ng/L).	The targeted time frame to achieve, to the extent practicable, is 30 years following remediation (assuming 10 years of remediation for a total of 40 years).
Time Post-remediation Necessary to Achieve PCB Loads from the Lower Fox River to Green Bay that Are Equivalent to the Sum of PCB Loads from Green Bay Tributaries	Number of years necessary to meet Green Bay tributary loads of 10 kg/yr PCBs.	The targeted time frame to reduce PCB loads to Green Bay and achieve source control is 30 years following remediation. For the monitored natural recovery alternative, the expectation is 40 years.

Table 10-1 Comparative Evaluation Measures (Continued)

Issue	Quantitative Measure	Comment
Time to Implement Cleanup Alternative	The estimated number of years for implementation of each alternative.	Significant disruptions to the community are expected to occur during implementation of the alternatives. The disruption may be caused by a number of factors, including: noise, environmental releases (air emissions and sediment resuspension), diminution of recreational use of the river, presence of heavy equipment, truck traffic, etc. The expected disruption of local communities is expected to be similar for all alternatives during the construction period. The alternatives do, however, vary considerably with respect to the expected time for completion of construction activities. For these reasons, the expected time of construction is considered an objective measure of the level of disruption to local communities.
Mass of PCBs Removed	Mass of PCBs removed from the river (kg).	The mass of PCBs removed from the river as a result of remediation is considered an objective measure of the permanence of the remedial option as it relates to environmental conditions within the river.
Cost	Estimated total alternative cost ($M).	The total cost provides a direct measure of the estimated funds to implement a remedial alternative. Total costs include capital costs, indirect costs, and annual operation and maintenance costs. For cost breakdown information, please see Table 10-2. For detailed cost estimates, please see Appendix H.
Incremental Cost to Reduce Years to Reach Protective Levels	Incremental cost (in $M/yr).	This measure represents the incremental cost of reducing the years to achieve protective levels to recreational anglers based on cancer risk by 1 year, and is considered a measure of the cost-to-benefit ratio of the alternatives. It is calculated as: $\left[\frac{Alternative\ Cost - Natural\ Attenuation\ Cost}{Natural\ Attenuation\ Years - Alternative\ Years}\right]$.

Table 10-2 Summary of Remedial Costs and Risk Reduction for Lower Fox River Remedial Alternatives

Lower Fox River Reaches	Remediation Alternative	PCB Action Level (ppb) 125	250	500	1,000	5,000	Maximum Action Level that Meets Risk Reduction Criteria Related to Project RAOs: RAO 1 SWQ	RAO 2 HH	RAO 3 Eco	RAO 4 Transport
Little Lake Butte des Morts	Impacted Volume (cy)	1,689,173	1,322,818	1,023,621	784,192	281,689				
	PCB Mass (kg)	1,838	1,814	1,782	1,715	1,329				
	Remedial Cost (in 1,000s $)									
	A/B: No Action	$9,900	$9,900	$9,900	$9,900	$9,900				
	C1: Dredge, Off-site Disp. (Pass. Dewater)	$231,500	$185,600	$147,800	$116,700	$48,500				NA
	C2: Dredge, Off-site Disp. (Mech. Dewater)	$126,200	$102,500	$82,800	$66,200	$28,300				
	D: Dredge to CDF, Off-site TSCA Disp.	$116,000	$110,300	$105,100	$68,000	$54,500				
	E: Dredge and Thermal Treatment	$117,200	$96,000	$78,500	$63,600	$29,300				
	F: Cap and Dredge to CDF	$145,200	$138,600	$99,300	$90,500	$66,200				
Appleton to Little Rapids	Impacted Volume (cy)	182,450	80,611	56,998	46,178	20,148				
	PCB Mass (kg)	106	99	95	92	67				
	Remedial Cost (in 1,000s $)									
	A/B: No Action	$9,900	$9,900	$9,900	$9,900	$9,900				NA
	C: Dredge, Off-site Disp.	$38,300	$25,000	$21,700	$20,100	$16,500				
	E: Dredge and Thermal Treatment	$26,200	$19,700	$17,900	$17,100	$15,200				
Little Rapids to De Pere	Impacted Volume (cy)	1,483,156	1,171,585	776,791	586,788	186,348				
	PCB Mass (kg)	1,210	1,192	1,157	1,111	798				
	Remedial Cost (in 1,000s $)									
	A/B: No Action	$9,900	$9,900	$9,900	$9,900	$9,900				
	C1: Dredge to NR 500 Facility (Pass. Dewater)	$224,200	$180,700	$124,200	$95,100	$38,100				
	C2A: Dredge to Comb. Dewater/Disp. Facility	$72,300	$63,200	$51,400	$43,900	$32,400				NA
	C2B: Dredge to Sep. Dewater/Disp. Facilities	$179,800	$152,800	$118,300	$99,900	$65,300				
	C3: Dredge to NR 500 Facility (Mech. Dewater)	$161,700	$130,800	$90,300	$69,100	$28,400				
	D: Dredge to CDF, Off-site TSCA Disp.	$72,300	$66,800	$58,400	$52,500	$44,400				
	E: Dredge and Thermal Treatment	$142,700	$123,800	$99,500	$86,200	$61,900				
	F: Cap and Dredge to CDF	$143,700	$114,300	$87,800	$62,900	$34,700				
De Pere to Green Bay	Impacted Volume (cy)	6,868,500	6,449,065	6,169,458	5,879,529	4,517,391				
	TSCA Volume (cy)	240,778	240,778	240,778	240,778	240,778				
	PCB Mass (kg)	26,620	26,581	26,528	26,433	24,950				
	Remedial Cost (in 1,000s $)									
	A/B: No Action	$9,900	$9,900	$9,900	$9,900	$9,900				
	C1: Dredge to NR 500 Facility (Pass. Dewater)	$769,100	$723,100	$692,300	$660,600	$511,100				
	C2A: Dredge to Comb. Dewater/Disp. Facility	$196,000	$186,900	$180,400	$173,500	$138,700				
	C2B: Dredge to Sep. Dewater/Disp. Facilities	$564,500	$534,100	$513,500	$491,800	$388,000				
	C3: Dredge to NR 500 Facility (Mech. Dewater)	$595,200	$561,000	$537,800	$513,500	$397,200				
	D: Dredge to CDF, Off-site TSCA Disp.	$611,800	$566,400	$536,200	$505,100	$360,700				
	E: Dredge and Thermal Treatment	$404,500	$384,000	$370,000	$355,100	$283,300				
	F: Cap and Dredge to CDF	$432,600	$403,900	$381,900	$357,100	$234,400				



Notes:

20% contingency costs not included.

Threshold criteria used to evaluate risk reduction:

RAO 1: 1 = Wildlife Criteria 30-year, 2 = Human Surface Water Drinking Criteria 30-year.

RAO 2: 1 = High-intake Fish Consumer Cancer 30-year, 2 = High-intake Fish Consumer Noncancer 30-year, 3 = Recreational Angler Cancer 10-year, 4 = Recreational Angler Noncancer 10-year.

RAO 3: 1 = Carnivorous Bird Deformity NOAEC 30-year, 2 = Piscivorous Mammal NOAEC 30-year.

RAO 4: 1 = Tributary Load to Reach Green Bay Level 30-year.

NA - Not applicable.

Action Level (ppb) that Consistently Meets Criteria after 10 or 30 Years of Recovery after Remediation Completion

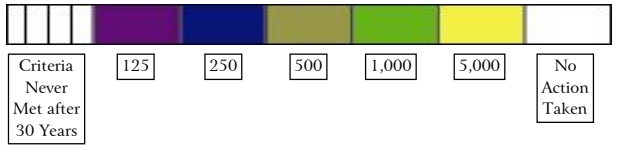


Table 10-3 Summary of Remedial Costs and Risk Reduction for Green Bay Remedial Alternatives

Green Bay Zone	Remediation Alternative	Action Level (ppb)					Maximum Action Level that Meets Risk Reduction Criteria Related to Project RAOs			
		125	250	500	1,000	5,000	RAO 1 SWQ	RAO 2 HH	RAO 3 Eco	RAO 4 Transport
							1 2	1 2 3 4	1 2	1
Green Bay Zone 2	Impacted Volume (cy)	NE	NE	29,748,004	29,322,254	4,070,170				
	PCB Mass (kg)	NE	NE	29,896	29,768	6,113				
	Remedial Cost (in 1,000s $)									
	A/B: No Action	NA	NA	$9,900	$9,900	$9,900	NE			NA
	C: Dredge, Off-site Disp.	NA	NA	NA	NA	$507,200				
	D: Dredge to CDF, Off-site TSCA Disp.	NA	NA	$824,700	$814,100	$166,500				
	G: Dredge to CAD	NA	NA	$707,400	$697,800	$124,000				
Green Bay Zone 3A	Impacted Volume (cy)	NE	NE	16,328,102	14,410	NE				
	PCB Mass (kg)	NE	NE	2,156	2	NE				
	Remedial Cost (in 1,000s $)									
	A/B: No Action	NA	NA	$9,900	$9,900	NA	NE			NA
	C: Dredge, Off-site Disp.	NA	NA	NA	$11,000	NA				
	D: Dredge to CDF, Off-site TSCA Disp.	NA	NA	$474,300	NA	NA				
	G: Dredge to CAD	NA	NA	$389,100	NA	NA				
Green Bay Zone 3B	Impacted Volume (cy)	NE	NE	43,625,096	NE	NE				
	PCB Mass (kg)	NE	NE	4,818	NE	NE				
	Remedial Cost (in 1,000s $)									
	A/B: No Action	NA	NA	$9,900	NA	NA	NE			NA
	D: Dredge to CDF, Off-site TSCA Disp.	NA	NA	$1,155,100	NA	NA				
	G: Dredge to CAD	NA	NA	$1,010,900	NA	NA				
Green Bay Zone 4	Impacted Volume (cy)	NE	NE	0	NE	NE				
	PCB Mass (kg)	NE	NE	0	NE	NE				
	Remedial Cost (in 1,000s $)									
	A/B: No Action	NA	NA	$9,900	NA	NA	NE			NA

Notes:

20% contingency costs not included.

Threshold criteria used to evaluate risk reduction:

RAO 1: 1 = Wildlife Criteria 30-year, 2 = Human Surface Water Drinking Criteria 30-year.

RAO 2: 1 = High-intake Fish Consumer Cancer 30-year, 2 = High-intake Fish Consumer Noncancer 30-year, 3 = Recreational Angler Cancer 10-year, 4 = Recreational Angler Noncancer 10-year.

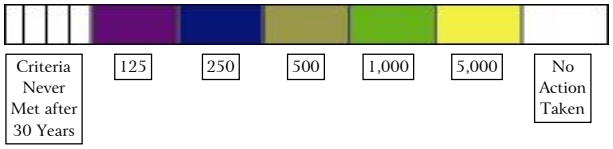
RAO 3: 1 = Carnivorous Bird Deformity NOAEC 30-year, 2 = Piscivorous Mammal NOAEC 30-year.

RAO 4: 1 = Tributary Load to Reach Green Bay Level 30-year.

NA - Not applicable.

NE - Not evaluated.

Action Level (ppb) that Consistently Meets Criteria after 10 or 30 Years of Recovery after Remediation Completion



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